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LABOR HYGIENE AND THE BIOLOGICAL ACTION OF RADIO-FREQUENCY ELECTROMAGNETIC WAVES

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[Excerpt] ONE MECHANISM OF THE NONTHERMAL ACTION OF HIGH-INTENSITY SHF RADIATION ON BIOLOGICAL AND CHEMICAL MOLECULAR COMPOUNDS, A. T. Polukhin, Moscow, p 65

We know that intense changes occur in time in molecular compounds due to fluctuating breakage of molecular bonds. This paper derives formulas permitting computation of the life span of molecular compounds as limited by the processes of their decomposition associated with thermal fluctuations. It is shown that high-intensity SHF [superhigh-frequency] radiation can significantly reduce this life span of molecular compounds by its action. Evaluations are presented using substances containing bound water molecules as an example.

THE PROBLEM OF THE EFFECT OF LOW-INTENSITY MILLIMETER SHF RADIATION ON HEMOGLOBIN, S. A. Il'ina, V. A. Kudryashova, and A. T. Polukhin, Moscow, pp 65-66

This paper analyzes experimental data on the effect of low intensity millimeter SHF on hemoglobin. The principal experimentally detected properties of this effect are presented, to include:

a) Its resonant nature (the maximum effect is achieved when the wavelength of the SHF radiation is on the order of 7 mm);

b) the need for prolonged irradiation to make the effect noticeable;

c) persistence of the effect of SHF radiation on hemoglobin over a long period of time after irradiation is terminated.

It is demonstrated that these properties can be explained if we consider the action of ionic-electrostatic forces of repulsion on some semifree molecular dipole groups in the hemoglobin molecule (His. E7).

GAS AND ENERGY METABOLISM IN RABBITS IN RESPONSE TO THE EFFECT OF MICROWAVES ON REGIONS OF THE RABBIT BRAIN, A. Sh. Ismailov, A. A. Aliverdiyev, and O. A. Krylov, Makhachkala, pp 66-67

Research was conducted on developing rabbits aged 2-4.5 months. Microwaves in the 852-283 MHz range with an intensity of 100 mw/cm^2 were used for local

irradiation of regions of the brain (the cerebral hemispheres and cerebellum -- the head irradiation area was 3 cm^2). In order to separately evaluate the thermal and specific action of microwaves, some of the experimental animals were subjected to the thermal effect using a special thermocouple.

The rabbits were irradiated for 30 minutes once every 2 days for 2 months. After each half month the weight of the animals, the pulse, respiration rate, lung ventilation, oxygen consumption, and carbon dioxide gas elimination were recorded.

The data obtained demonstrate that irradiation of parts of the central nervous system in young developing rabbits noticeably retards their growth and development as compared to control animals (A. Sh. Ismailov, 1970), which agrees with the data of M. S. Tolgskaya and Z. V. Gordon (1971), who also observed a reduction in animal body weight during chronic SHF irradiation. An equivalent thermal effect on the corresponding rabbit brain regions (the cerebral hemispheres and cerebellum) also produces the same effect, but it is not as pronounced.

Both the action of heat and microwaves on brain regions causes the pulse to drop. Respiration frequency dropped only when the region of the cerebral hemispheres is irradiated for 2 months. Oxygen consumption by the animals increases upon irradiation of the cerebellum, and it decreases upon irradiation of the cerebral hemispheres.

Heating and irradiation of brain regions leads to differently pronounced reduction of carbon dioxide gas liberation. First the energy expenditures of rabbits per unit weight are lower than normal upon irradiation of particular brain regions and higher than normal upon heating. Later the energy expenditures approach the normal values.

Half a month after heating of brain regions is stopped, all studied indices of rabbits returned to normal, while among animals subjected to microwave irradiation many indices (pulse, carbon dioxide gas liberation, respiratory coefficient, and energy expenditures) continued to differ from normal.

The observed changes in indices of gas and energy metabolism upon irradiation of various regions of the rabbit brain by microwaves can be explained, from our point of view, as a direct action of microwaves on brain structures (due to significant penetration of decimeter waves), and by their effect on receptor fields of sections of skin on the head subjected to irradiation.

THE PROBLEM OF THE NATURE OF THE COURSE OF ALLERGIC PROCESSES ON THE BACKGROUND OF SHF ENERGY EFFECTS, G. I. Vinogradov, I. M. Karandakova, and Ye. M. Makarenko, Kiev, pp 67-68

The study presented in this communication was directed at revealing the nature and intensity of allergic reactions to the effect of two harmful factors -- a chemical allergen and SHF energy.

Experimental research was conducted on guinea pigs. Sensitization was conducted with a well-known allergen -- phthaline anhydride -- daily, intraperitoneally at a dose of 0.15 mg for 14 days. A Luch 58 apparatus (constant magnetic field, 50 mw/cm^2) was used as a source of SHF radiation for 14 days, 5 hours a day.

All guinea pigs were separated into four groups. Animals of the first group were subjected first to sensitization and then to irradiation, the second group was subjected to irradiation followed by sensitization, and the third group was subjected to simultaneous sensitization and irradiation. Guinea pigs of the fourth group served as a control. The presence of antibodies in serum was determined in dynamics by the cold complement fixation reaction. A suspension of brain tissue from irradiated and nonirradiated animals as well as brain tissue from animals subjected to the action of phthaline anhydride were used as the antigen.

The research results demonstrated that injection of phthaline anhydride causes formation of antibodies in a titer of 1:80-1:160 in brain tissue of animals sensitized with this allergen. After irradiation of these animals we were unable to detect antibodies for the antigen made of brain tissue. Subsequent serological research on brain antibodies in this group of animals also failed to produce positive results -- that is, SHF irradiation led to inhibition of antibody formation in this case. An analysis of the complement fixation reaction data for the second group demonstrated the presence of autoantibodies in a titer of 1:160-1:320 against antigen from irradiated brain tissue immediately after termination of the SHF energy effect. Subsequent injection of phthaline anhydride did not change the titer of brain antibodies. The antibody titer began to drop only 2 and 4 weeks after termination of the sensitization cycle. However, in this group we were unable to reveal antibodies against brain tissue altered in response to phthaline anhydride in any of the stages.

Simultaneous sensitization of guniea pigs with phthaline anhydride and exposure to an SHF field inhibited synthesis of antibodies against brain tissue altered by phthaline anhydride and, on the other hand, to some extent it promoted formation of specific antibodies against irradiated tissue.

Summarizing the results obtained, we can conclude that SHF energy has a sensitizing action, causing autoantibody formation in the irradiated body. At the same time, combined allergenic action of SHF energy and a chemical promotes, under the particular experimental conditions, inhibition of the allergic reaction to one of the sensitizing agents.

EFFECT OF DECIMETER WAVES ON LIVER MITOCHONDRIA OF RABBITS WITH ADJUVANT POLYARTHRITIS AND NORMAL RABBITS, S. M. Zubkova, A. I. Zhuravlev, V. D. Grigor'yeva, and A. I. Zol'nikova, Moscow, pp 68-69

The task of the present study was to reveal the possibilities for a directed effect of decimeter waves on redox processes occurring in mitochondria under normal conditions and when the body is in a pathological state, particularly upon development of experimental adjuvant polyarthritis.

Experiments were conducted with 49 male rabbits weighing an average of 3 kg. A Volna-1 apparatus was used to irradiate the rabbits with decimeter waves ($\lambda = 65$ cm) by the contact method (using a ceramic emitter 40 mm in diameter) in the area of the adrenal glands. The irradiation intensity was 110 mw/cm^2, the irradiation time was 10 minutes, and the treatment duration was 12 days. Experimental polyarthritis was produced in rabbits using a single injection of Freund's adjuvant. Mitochondria were isolated from the liver of studied animals by separation centrifugation. A polarographic method was used to determine the intensity of mitochrondial respiration in both phosporylational (addition of ADP) and free oxidation (addition of 2,4-dinitrophenol).

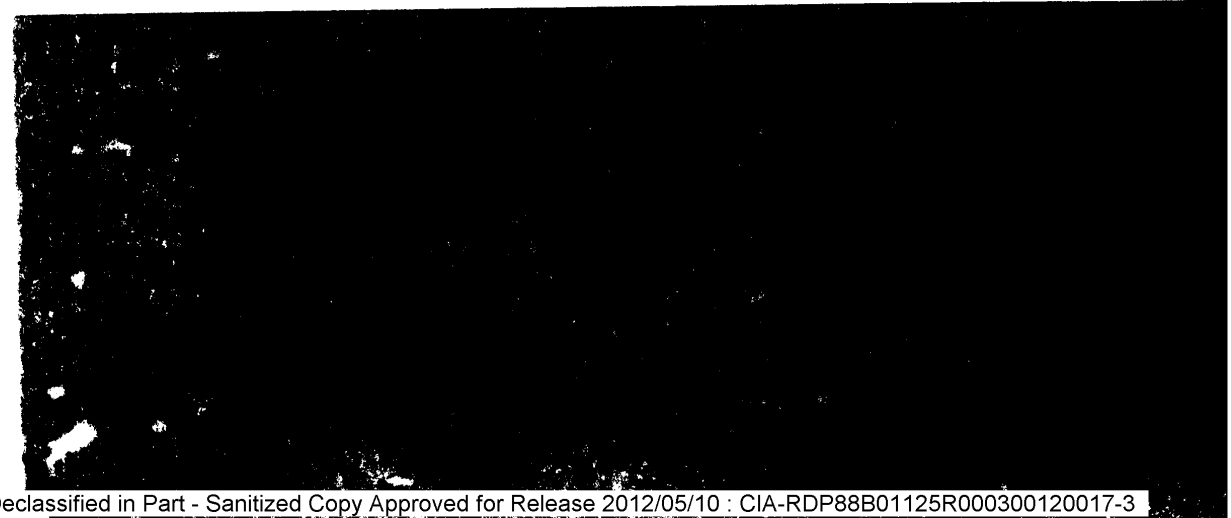
It was demonstrated that exposure of the adrenal region of healthy rabbits to decimeter waves affects the metabolic state of liver mitochondria as a very mild, weak, stimulant, having only a moderate uncoupling action accompanied by activation of oxidative processes. This effect persists 20 days after the course of decimeter wave treatment.

An opposite pattern holds in response to pathogenic Freund's adjuvant: Stress-type changes occur, and oxidation of the substrate (succinate) is restricted and inhibited. In this case these changes are most clearly pronounced when experimental polyarthritis is induced later (48-52 days).

Decimeter wave treatment has a partially normalizing action on energy metabolism in liver mitochondria of rabbits impaired by polyarthritis. This normalizing action is more clearly pronounced when experimental polyarthritis is induced earlier (30-32 days), as compared to later (48-52 days).

INTERPRETATION OF ECG CHANGES IN RESPONSE TO THE ACTION OF A HIGH-FREQUENCY ELECTRIC FIELD, I. M. Gorpinchenko, Moscow, pp 69-70

An isolated frog heart was subjected to the action of a 300 MHz electric field with an intensity range of 2.1-11.5 volts/cm for 40 seconds to 2.5 minutes. The ECG was recorded. In all cases the amplitude of the R-wave was reduced, and the width and amplitude of the T-wave increased. Treatment of results describing the behavior of the T-wave demonstrated that after the exposure is terminated its parameters return practically to normal. The increase in T-wave parameters occurs at a rate much higher than that with which the heart rhythm frequency rises, reflecting primarily the growth in the object's temperature as a result of absorption of the field's energy. The difference in rates of these effects characterizes the specificity of the field's action.

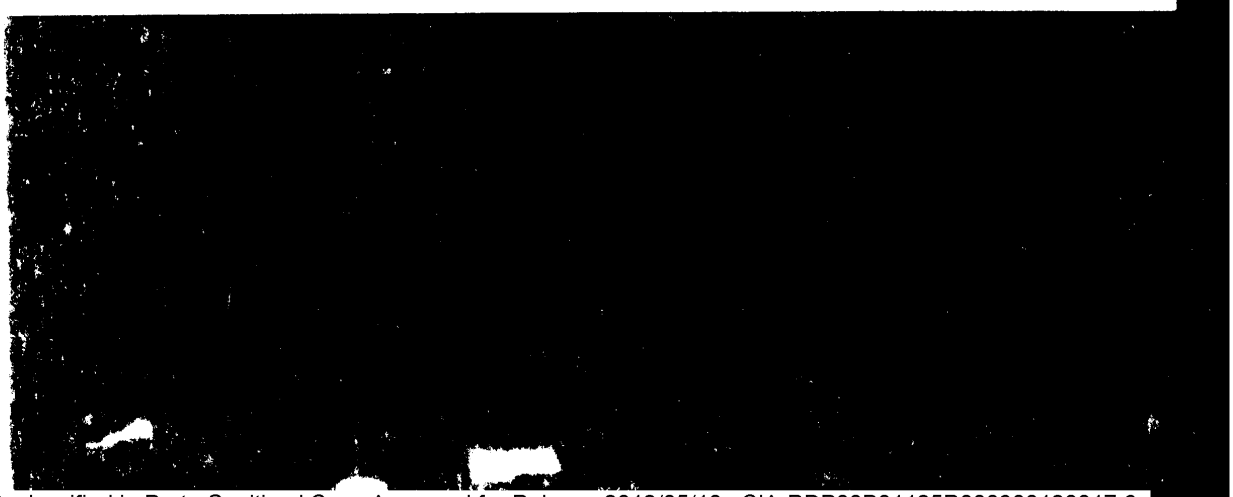


An interpretation of the ECG changes can be given at the physioochemical level. It is based on the ferroelectric (FE) properties of tissue electrolytes discovered by the author. As we know, there is a hysteresis dependence between polarization and the electric field in FE materials. This means a dielectric hysteresis loop exists in both the cell and the medium. When the field reaches a critical (threshold) value an action potential (PD) arises representing the SE repolarization current. Thus as a result of electrostatic induction both of these processes occur in both the cell and the medium, such that the ECG represents the results of the summation of biphasic PD of the cell and the PD of the medium. In this case the first half-wave (phase) of the PD is the depolarization phase, while the second half-wave is the repolarization phase. The T-wave is the result of summation of the trailing edges of the depolarization phases of both PD.

When a high-frequency electric field affects an FE material in a low-frequency electric field, the hysteresis loops are rectified and increased in size. The FE repolarization current rises and becomes shorter due to this. This signifies constriction and growth of the PD in relation to the dielectric hysteresis loops of the cell and medium (the low frequency in the examined case corresponds to the heart rhythm frequency, while the high frequency corresponds to the frequency of the acting fields). However, the rate at which the leading and trailing edges of the cell PD and medium PD grows differs in this case. The PD leading edges depend upon protrusion of the ferromagnetic domain through the space, while the trailing edges depend on formation of embryonic domains. Moreover, a reduction in viscosity brings the origins of the cell PD and medium PD closer together. This can be assumed to be the primary cause for reduction of the R-wave when the leading depolarization edges of both PD are summated.

We know that embryonic domains are formed predominately at interfaces: Therefore there are more of them in a cell, which is a heterogenic system, than in the medium. Thus we can hypothesize that the trailing edge of the depolarization phase of the cell PD increases in response to a field more quickly then does that of the medium PD. Summation of these fronts causes a larger T-wave.

The proposed interpretation of the ECG matches existing interpretations of the ECG as a result of summation of 2 PD. The essential difference is that biphasic cell PD and medium PD are summated, rather than uniphasic PD from different parts of the heart. This interpretation of ECG changes in response to the effect of a high-frequency field on an object permits and necessitates additional experiments, and it presupposes a certain contribution to the study of the physicochemical mechanism underlying biological action of electromagnetic fields.



SOME NONPROPORTIONAL DEPENDENCIES IN THE ACTION OF LOW- AND RADIO-FREQUENCY ELECTROMAGNETIC FIELDS AT THE CELLULAR AND ORGANISMIC LEVELS, Ye. T. Kulin, Minsk, pp 70-71

Using phagocytosis in unicellular animals (*Paramecium*) as an example, it is shown that in some cells this function changes nonproportionally in regard to linear changes in the frequency, intensity, and exposure time to an electromagnetic field in the 10^6-$6 \cdot 10^8$ Hz range. This was expressed in appearance of cytophysiological changes within restricted zones of change of the indicated parameters when the intensity of the field was small. The effects are clearly revealed cumulatively in suspensions of *Paramecium* when the suspension is dominated by cells that change their function identically in response to changes in a particular parameter of the electromagnetic field.

Nonproportional changes were demonstrated in multicellular organisms -- some species of arthropods -- in their motor activity in the presence of linear changes in the frequency, intensity, and exposure time to the field. This was expressed in sharp accelerations or decelerations of their movements within specific narrow frequency bands typical of each species (10 kHz, 100 kHz, 160 kHz, 1 MHz, and 400 MHz) while the remaining parameters of the field were kept constant, and in the presence of threshold values for field intensity and exposure time, above which the magnitude of the effect did not change significantly.

It was demonstrated by exposing *Drosophila* and barley sprouts to 10^6-$6 \cdot 10^8$ Hz fields that the yield of mutants in *Drosophila* and of chromosome aberrations in sprout cells varied nonproportionally with respect to linear changes in field frequency and intensity. In particular, two frequencies were effective for *Drosophila* -- 300 and 400 MHz, while six were effective for barley -- 340, 360, 400, 410, 440, and 540 MHz. In this case the total heating of the seeds did not correlate with the observed effects.

Considering that the described nonproportional changes in function were observed in different organisms, this nonproportional dependence of the reactions of a living system to a field can be interpreted as a manifestation of one of the laws of the biological action of low- and radio-frequency electromagnetic fields.

The presence of a nonproportional dependence between changes in physiological and genetic functions and linear changes in the parameters of an electromagnetic field permits us to hypothesize that some living organisms have regulatory systems that are able to respond to a particular combination of field parameters and have an effect on the course of vital processes.

THE PRESENT STATUS OF THE PROBLEM OF INTERACTION BETWEEN RADIO-FREQUENCY FIELDS IN CIVIL AVIATION, I. Ya. Loshak, Moscow, pp 71-73

The development of radioelectronic equipment and the role it must play in insuring flight safety promote continual growth in the amount of different

types of radio apparatus at airports. One peculiarity of this process is that it is accompanied by a relatively small increase in the numbers of personnel at radio engineering facilities, since automation, remote control, and so on are employed, while the number of individuals subjected to radiation outside of their occupations increases.

The radio wave background of airports consists primarily of SHF radiation from ground radar stations and, to a lesser degree, of high-frequency fields created by radio navigation and radio communication resources. Antennas of ground radio facilities are the principal source of occupational and non-occupational radio-frequency electromagnetic radiation. Such radiation is complex, predominantly discrete and intermittent. Exposure is variable in duration, it is aperiodic, but it is sufficiently regular.

The irradiation levels are quite variable. However while we can generally note a certain reduction in its average value at radio facilities owing to better shielding of transmitting apparatus and wave guide channel elements, as well as owing to other protection methods employed, the intensity of nonoccupational exposure has risen. This pertains primarily to technicians of the ground services, who must work constantly in the airport area for a long time. In a number of airports the magnitude and duration of irradiation of such individuals is higher than for personnel of radio facilities. In this case growth in the proportion of emissions from aircraft radar due to the present requirements for testing the operability of the system is presently typical of the structure of such irradiation. It is very difficult to deal with radar emissions.

The results of dynamic observations on the state of health of specialists in the communications and radio navigation services indicate that the number and extent of changes that would be pathognomonic in relation to chronic exposure to radio-frequency electromagnetic fields is decreasing somewhat. However, the percentage of such diagnoses as "autonomic dystonia," "autonomic dysfunction," "an asthenic condition," and so on continues to be rather high.

A comparative analysis of morbidity involving temporary incapacitation among individuals subjected to occupational and nonoccupation irradiation by radio-frequency electromagnetic fields demonstrated that the number of cases and number of days lost were 1.5 and 1.6 times higher in the former as compared to a control group, and 1.2 and 1.5 times higher in the latter. The average duration of a single case of illness is also higher. These differences are especially noticeable in regard to diseases of respiratory organs, and less so in relation to diseases of the heart, nervous system, and gastrointestinal tract (growth in the number of the latter is symptomatic for morbidity of the group being studied).

Under the conditions of a modern airport, where workers are subjected to the influence of an entire complex of unfavorable industrial factors, radio-frequency radiation is becoming primary from the quantitative standpoint. In addition to the "traditional" radio wavelengths, we are making continually

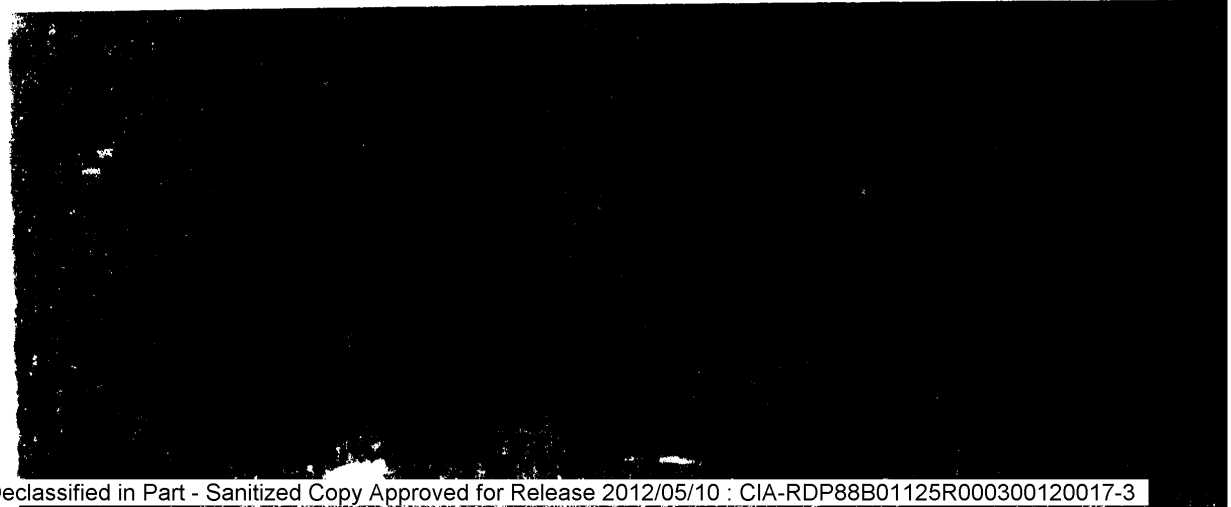
broader use of millimeter waves and of new areas of the centimeter spectrum. Optic quantum generators are also being introduced. At the same time insufficient knowledge of some biological laws governing the effects of this factor, primarily those associated with features of the radiation, makes it difficult to enact appropriate preventive measures.

ASSESSMENT OF THE DANGER OF SHF RADIATION WHEN OPERATING METEOROLOGICAL RADAR STATIONS, N. D. Khramova, V. I. Timoshin, V. I. Belov, and V. A. Miroyedov, Moscow, pp 73-74

Radar systems operating in the millimeter and centimeter wave bands have achieved broad application today in the hydrometeorological service to detect, observe, and determine the location of cloud systems, thunderstorm centers, and heavy showers.

The highly strict methods for quantitatively assessing an electromagnetic field in which a cumulative polar diagram is obtained for antennas with a circular sweep, with which these stations are equipped, and the approximate computations of the lateral field of an antenna using maximum envelopes require complex mathematical computations, they do not consider the instability of emitter parameters, and they do not guarantee against errors due to the inadequacy of the theory with respect to the real conditions under which SHF energy propagates and spreads locally. Therefore the chief method for quantitatively determining the danger of SHF radiation at places of work and in population centers is the method of instrument measurements. The existing apparatus for measuring the PPM [expansion unknown] of an electromagnetic field in the SHF range permits us to make measurements with sufficiently high accuracy, and the existing procedures of instrument measurements and of their treatment permit us not only to obtain data on the intensity of radiation from radar stations at a particular point, but also to reveal the laws governing the distribution of PPM, which are common to a given type of station located anywhere.

In this paper instrument measurements made locally are correlated with the axis of the main lobe of the antenna's emission diagram. The main lobe presents the greatest danger in radiation, and the measurements themselves are made according to a strictly determined system in which PPM levels are measured at different tilt angles with respect to the axis of the main lobe, at different heights above the ground and at different distances from the radiation source. The data were processed employing the methods of mathematical statistics. The average field intensity of the station was determined as the mathematical expectation of a random variable employing PPM level values obtained at identical distances in all studied directions and elevations. The graphs plotted from statistically treated measurements can be used to determine the PPM of fields generated by meteorological radar systems at different distances from the station for altitudes from 1 meter to 16 meters and at different antenna elevations, taking account of local relief.



The measurements were used to determine the dangerous zones of meteorological radar systems. They can be used to define and conduct measures by which to provide collective protection to maintenance personnel and the surrounding population having the purpose to reduce the degree of irradiation experienced from SHF fields produced by meteorological radar systems.

A HYGIENIC DESCRIPTION OF HIGH- AND SUPERHIGH-FREQUENCY ELECTROMAGNETIC RADIATION ON SEAGOING VESSELS, L. M. Matsevich, Yu. I. Rezina, and A. P. Yerusalimskiy, Moscow, pp 74-75

Intensive use of radio navigation apparatus in the modern marine fleet means that high-frequency and SHF electromagnetic radiation arises on ships.

Radio transmitters (middle-wave, shortwave, and ultrashortwave) are the sources of high-frequency energy.

SHF energy is emitted when radar stations operate. Research conducted on seagoing transporters and icebreakers demonstrated the following.

The intensities of high-frequency fields arising at the radio operator's working place exceed the maximum norms for electromagnetic radiation on ships. This is the case when ship radio stations operate on steamships of the Omsk, Volgoles, Andizhan, and other classes.

Exposed feeder channels and antenna switches are the principal sources of electromagnetic radiation.

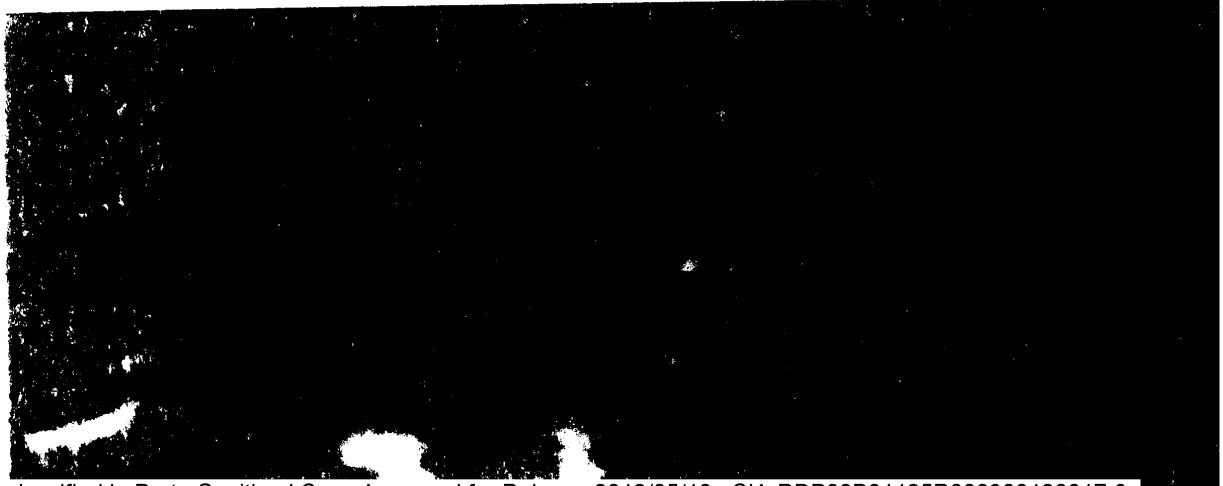
In some cases the absence of shielding about radio rooms causes electromagnetic fields to penetrate into adjacent spaces. As a rule the transmitters and blocks of radar stations are located in special shielded rooms, precluding propagation of SHF energy into living and service quarters.

Not only radio operators but also all members of the crew are subjected to the unfavorable effects of radio-frequency electromagnetic fields on ships when they are on exposed decks.

When the radio station is operating, high-frequency radiation from transmitting antenna is recorded along the entire length of the ship. The greatest intensity of the high-frequency electromagnetic field is noted at the down leads of the antennas (over 1,000 volts/meter).

The intensity of SHF radiation on ship decks depends on the height of the antenna and the architectural features of the ship. When the antenna is less than 5 meters above the nagivation bridge, the field intensity reaches 8-20 $\mu w/cm^2$.

When escorting a caravan, icebreakers may find themselves in the emission zone of the radar stations of ships being escorted. In such cases the



intensities of the SHF fields on exposed decks exceed the maximum norms for individuals not occupationally involved with the radiation.

Combination of the effects of climatic (low and high ambient air temperatures) and ship factors (noise, vibration, microclimate, and so on) on long cruises aggravates the unfavorable effect of radio-frequency electromagnetic fields on the bodies of seamen.

The conducted research made it possible to develop a number of hygienic recommendations on protecting ship crew members from the effects of intense high-frequency and SHF electromagnetic fields.

HYGIENIC PRINCIPLES OF THE SCIENTIFIC ORGANIZATION OF LABOR AT RADIO TRANSMITTING AND TELEVISION STATIONS, P.P. Fukalova, Moscow, pp 75-76

One consequence of scientific-technical progress in our country is expansion of the network of radio broadcasting and television stations, and use of artificial earth satellites to transmit television programs and organize communications over great distances.

One of the main conditions for successfully completing the task of developing radio communication resources and increasing the effectiveness of the work of radio communication enterprises is creating favorable sanitary-hygienic conditions and improving the organization of labor such as to insure that the working ability of personnel is high.

The fundamental principles and standard concepts we had recommended earlier could not be implemented immediately at radio communication enterprises employing equipment that is imperfect from a hygienic standpoint and obsolete forms of labor organization. In a number of cases old equipment had to be replanned and replaced by new equipment, and the principal requirements of scientific organization of labor at reconstructed and newly planned enterprises had to be considered so that these recommendations could be incorporated into the plan for scientific organization of labor and implemented integrally with other organizational, technical-aesthetic, ergonomic, and hygienic measures.

Replacement of multistaged unshielded cascades and circuits of superhigh-frequency transmitting devices by transmitters having new designs, replanning of the multiple-row disposition of shortwave transmitters as one- and two-row systems, replacement of manual switching by automatic switching, shielding the high-frequency underground cable routes, and so on produced a good hygienic impact expressed as a reduction in field intensity to a level of maximally permissible values and below.

Efficient solutions concerning apparatus position excluded the need for performing numerous, uncomfortable operations when managing radio transmission. The need was created for free access to the apparatus and for organizing clearly defined scheduled maintenance.

The methods of protection are defined by the specific production situation at radio communication and broadcasting stations with different layouts of production buildings and employing apparatus differing in quantity and location and working in different ranges.

Personnel are protected from radiation by the organization of remote control over transmitters from a separate building at television-radio stations employing, as a rule, standard building and apparatus layouts depending on the transmission schedule.

The unfavorable consequences of other environmental factors (heightened air temperature, noise) are eliminated integrally with the indicated measures for improving organization of labor and with various solutions of a sanitary engineering and hygienic nature.

Replanning, reconstruction, and new construction with a consideration of the requirements of technical aesthetics promotes comfort in working buildings in terms of color and light.

PREVENTIVE ASPECTS OF HYGIENIC EVALUATION OF WORKING CONDITIONS IN RADIO STATIONS AND TELEVISION STATIONS, G. Mikolaychik, Lodz', Poland, pp 76-77

Until recently, hygienic assessments of working conditions in radio and television stations had concentrated almost exclusively on electromagnetic fields, the intensity of which with respect to the electric component fluctuated at working places from 10 to several tenths of a volt per meter. In recent years we have been able to reduce the field intensity with technical resources to lower values (from a tenth to several volts/meter). Despite the fact that the field intensity has been reduced significantly, the number of complaints being submitted by workers at radio and television stations is not diminishing. This forced us to turn our attention to other environmental factors.

Research and measurements demonstrated that there is a special microclimate in the transmitter buildings of radio and television stations, and that the transmitters produce noise when they work. In these buildings the microclimate is typified by temperature, reaching 35°C, and comparatively low relative humidity (below 40 percent). Thus the main parameters of the microclimate differ from optimum values in relation to effects on the human body. The acoustic pressure fluctuates within 70-85 db with an N [expansion unknown] index of 69-78. Such noise levels are unfavorable at the working places, requiring significant concentration of attention, as is the case when radio and television transmitters must be serviced.

Special attention should be turned to the work and rest schedule. Workers work in two 12-hour shifts at the radio and television monitoring locations. In this case the day shift is followed by a 24-hour break, while the night shift is followed by a 48-hour break. Thus the work schedule is nonregular, and as a consequence the eating and sleeping schedule is arrhythmic.

Moreover, the radio and television station workers often use their free days for additional jobs, which leads to a deeper deficit in the amount of rest required by the body.

We can suggest that in addition to the significant progress that has occurred in reducing field intensity at working places and transmitter buildings of radio and television stations by means of technical resources, we are still far behind in optimizing the parameters of other environmental factors (air temperature and humidity, noise). Also, there are significant deviations from the norm in the organization and schedule of labor. Until optimum microclimate conditions, acoustic pressure levels, and labor organization are created, it would not be possible to answer the question as to whether or not electromagnetic fields lying within permissible hygienic norms have a harmful effect on the bodies of workers servicing radio and television transmitter.

RESULTS OF RESEARCH ON PROTECTING WORKERS FROM ELECTROMAGNETIC RADIATION AT RADIO AND TELEVISION TRANSMITTING STATIONS, N. V. Maksimenko, Khar'kov, p 78

The research conducted on 19 radio and television transmitting stations demonstrated that the intensity of electromagnetic fields at working places of maintenance personnel exceeds the maximum permissible value (5 volts/meter). For this reason the need arises for protecting workers from electromagnetic radiation. However, the problems involved (designing and building protective shields) pertaining to the meter-waveband have not been discussed adequately in the literature.

In this connection we conducted theoretical and experimental research (under laboratory and production conditions) on reticular shields and slotted shielding devices effective against the meter-waveband and which could be used to protect individuals from electromagnetic radiation.

The research produced formulas for computing the effectiveness of these shields.

An analysis demonstrated that the amount of electromagnetic attenuation by reticular shields located in direct proximity to the field sources depends significantly on the net parameter (mesh size), the shield dimensions, and the electromagnetic field wavelength, and insignificantly on the electric properties of the material and the distance to the field source (except for the center of a sphere, where it does not depend on distance). As far as slotted shields are concerned, attenuation depends on the nature of the field source (in the proximal zone), the number and parameters of the slots (lengths, widths), the field wavelength, the distance from the working place to the screen, and the screen's geometric dimensions. Sufficiently good agreement is noted between computed and experimental data.

The results of research described above made it possible to provide addi-

[illegible] of television

[illegible] station control panels.

Procedures were worked out on the basis of the theoretical and experimental research to design protective shields for the meter-wave range. Engineering recommendations on protecting workers from electromagnetic radiation at transmitting and radio and television stations were also made.

THE PROBLEM OF RADIATION INTENSITY AT POPULATED POINTS NEAR TELEVISION CENTERS, N. D. Khramova, V. A. Miroyedov, V. V. Yur'yev, Moscow, pp 79-80

The swift growth in municipal construction, the increase in area of cities and villages coupled with simultaneous expansion of radio broadcasting, communications, and television transmitting station networks, and the increase in their output capacities can lead to irradiation of the population by high- and ultrahigh-frequency radio waves that are undesirable and are not without an affect on health. Therefore the need arises for establishing medical protective zones. To define such zones we must do the following:

1. Reveal the existing levels of electromagnetic radiation in populated points generated by emitting antennas of high-power radio facilities.

2. Determine the dependence of field intensity on specific conditions (the type of emitting antenna, the topography of the populated point, and so on).

During 1970-1971 we made instrument measurements of the intensities of electromagnetic fields in the ultrashort-wave range near nine of the country's television centers located in the central belt and near the Baltic.

The height at which antennas are erected is standard. The exceptions are the Vinnitsa television center which has an antenna support 350 meters high, and the Riga television center in the Latvian SSR which has its antenna 100 meters above the ground.

A PZ-2 electromagnetic field intensity meter coupled with an additional interchangeable antenna used to increase the instrument's sensitivity was used to make local measurements. The instrument was calibrated with both the standard and the additional antenna on a test bench of the Leningrad Tekhnikum of Aviation Instrument Making and Automation.

The television centers of Tallin, Tartu, and Riga were studied in the greatest detail.

Research was conducted in three or four directions at a radius of up to 3 km. Measuring points were selected every 50-100 meters in each direction.

One- and two-story private structures (cottages, garden plots) are typical of the vicinity of the Tartu television center. Therefore research near this television center provides the most clear pattern of the field's distribution. The Tallin television center is located within a populated

distribution in the proximal zone more complex and reduces the average field intensity. A self-propelled lift was used to make measurements in Tallin. Thus the field intensity distribution pattern could be studied with respect to height (at 4, 8, and 12 meters).

According to our measurements the maximum electromagnetic field intensity is 2.3-2.7 volts/meter 100-150 meters from the emitting antennas.

The radiation level decreased to the value presently recommended as the maximum (1 volt/meter) at 250-400 meters.

At a range of up to 2.6-2.8 km from the radiation source the field intensity drops to 0.1 volts/meter.

The nature of electromagnetic field distribution in populated points as described by the envelope of the maximums agrees well with the computed graph of field intensity.

COMPUTATIONAL METHODS FOR DETERMINING ELECTROMAGNETIC ENERGY IN POPULATED POINTS, I. P. Los', Yu. D. Dumanskiy, V. M. Popovich, and A. M. Serdyuk, Kiev, pp 80-82

The continual growth in the number of radio transmitting stations is causing a significant rise in the intensity of radio-frequency electromagnetic energy in populated points. Doubtlessly the population is concerned. In this connection the question of rating the amount of radio-frequency electromagnetic energy in populated points and of developing measures to protect the population from the affect of this factor has become acute.

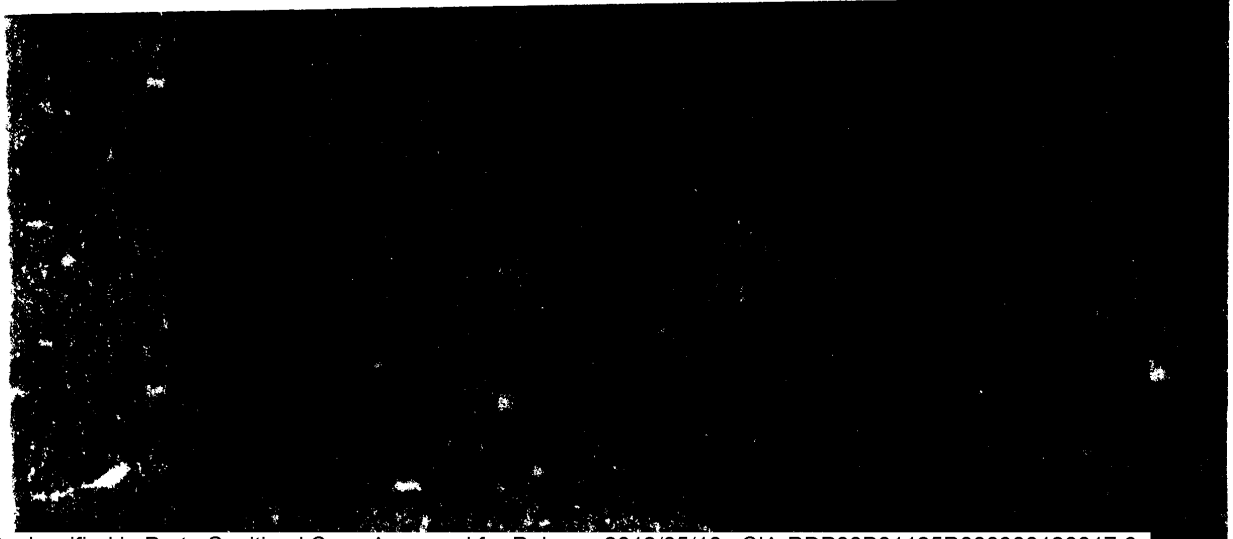
Considering this fact, medical preventive surveillance, which employs a method of determining the expected value of electromagnetic energy at a given distance from a radiation source, is presently acquiring especially great significance.

As a rule the methods presented in the literature for computing field intensity are applicable to great distances. Only some of the formulas can be used in medical preventive surveillance. They include Vvedenskiy's well-known formula:

$$E = \frac{2{,}10\sqrt{PD}}{d^2\lambda} \cdot h_1 h_2$$

where E is the expected field intensity, P is the transmitter power, D is the directivity factor, d is the distance from the antenna to the point at which E is determined, λ is the wavelength, and h_1 and h_2 are the heights of the transmitter and of the point at which E is determined.

But this formula has a very narrow range of application defined by the condition $h_1 h_2 \leq (d\lambda/18)$ -- that is, it can be applied only in the meter-wave range at commensurate heights h_1 and h_2.



Using as a basis an analysis of the existing methods for determing field intensity and the results of real measurements accumulated over a number of years, we developed a method for determining electromagnetic energy at close distances (hundreds and thousands of meters) satisfying the requirements of medical preventive surveillance.

The expected field intensity at a given point in the direction of maximum emission is determined with the expression:

$$E = E_0 \cdot F \cdot F(\Delta^\circ) \cdot K_1 \cdot K_2$$

where E_0 is the intensity of a field propagating in free space, F is an attenuation factor taking account of reflection of radio waves from the earth's surface, $F(\Delta^\circ)$ is a factor taking account of the antenna's polar diagram in the vertical plane, K_1 is a coefficient taking account of nonuniformity in radiation in the horizontal plane of a circular polar diagram, and K_2 is a factor taking account of the pulse duty factor when pulsed emission is involved.

The intensity of a field propagating in free space is usually determined with the relatioships:

$E = \frac{77.3\sqrt{P \cdot D}}{d}$ for antennas mounted low and

$E = \frac{57.0\sqrt{P \cdot D}}{d}$ for antennas mounted high and for television antennas.

The attenuation factor F is computed with special formulas for each radio wave range. It can be determined for the high-frequency range by the expression:

$$F = 1{,}41 - \frac{2 + 0{,}3x}{2 + x + 0{,}6x^2},$$

after first finding the numerical value of x from the expression:

$$x = \frac{\pi d}{\lambda} \cdot \frac{1}{\sqrt{(\Sigma')^2 + (60\sigma)^2} - \Sigma'},$$

where Σ' is the relative dielectric permeability of the soil strip along which the radio wave propagates and σ is the radio conductivity of the soil.

In the UHF, SHF, and KVCh [expansion unknown] ranges the attenuation factor can be assumed to equal 1.6 up to a distance $d_1 = 5.1(h_1 h_2)/\lambda$. At greater distances, $d_2 = 6.0(h_1 h_2)/\lambda$, F can be assumed to equal 1. In the interval between d_1 and d_2, F drops exponentially from 1.6 to 1. It can be determined using a specially plotted graph.

The value of factor $F(\Delta^\circ)$ is determined separately for each specific antenna with a consideration for its radiation pattern in the vertical plane, the height at which the antenna is mounted h_1, and distance d.

Factor K_1 is added to the formula only in the event that the antenna has a circular radiation pattern in the horizontal plane. For television antennas that are nondirectional in the horizontal plane, the factor is usually assumed to equal 1.4.

Factor K_2 is added to the formula only when it is necessary to determine the expected intensity of a field created by stations operating in the pulsed mode (radar stations). The value of the factor is determined for a specific station on the basis of the length of the emitted pulse and the pulse repetition rate.

PROPOSALS FOR ORGANIZING PUBLIC HEALTH PROTECTION ZONES FOR TELEVISION STATIONS, S. I. Dumanskaya, Kiev, pp 82-83

According to the public health hygienic standards, the maximum intensity of ultrashort-wave electromagnetic fields (EMF) permitted in populated points is 1 volt/meter. However, as research conducted by the Kiev Scientific Research Institute of General and Municipal Hygiene imeni A. N. Marzeyev showed, unfavorable changes occur in the body at even lower EMF levels if exposure to this factor is long, 10-12 hours per day.

Considering this fact, the institute recommended differentiation of the maximum permissible EMF levels:

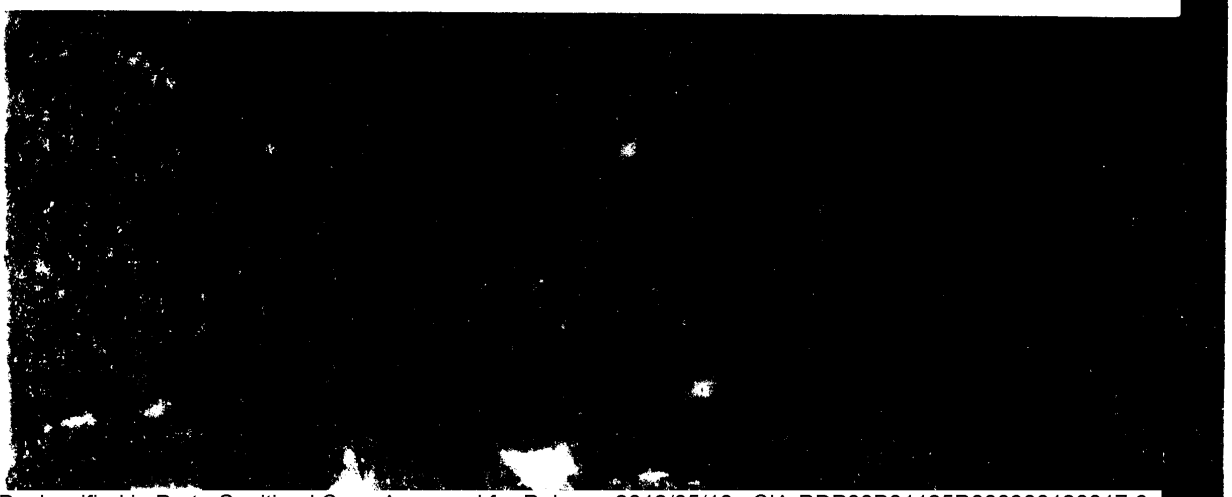
1) For open territory, where under urban conditions the time an individual is exposed to this factor is relatively short (1-3 hours per day) -- 1 volt/meter;

2) For enclosed structures in which the individual is exposed to this factor for a longer time (9-11 hours per day) -- 0.2 volts/meter.

On this basis as well as on the basis of the ways EMF propagate in the proximal emission zone, the shielding properties of the structures, and the effectiveness of planned protective resources, the public health protection zone of a television station should be split into two in order to make efficient use of the territory -- a strictly controlled zone and a zone of limited construction.

The EMF level should be 1 volt/meter at the boundary between the strictly controlled zone and the zone of limited construction, and 0.2 volts/meter at the outer boundary of the zone of limited construction.

The territory of the strictly controlled zone should be used only for the structures of the television complex itself -- that is, it is a technical territory. The territory of the zone of limited construction can be used for urban buildup on the condition that certain protective measures are enacted.



Urban buildup within the zone in which television stations have a harmful effect must permit free passage of radio waves and maximally exclude the probability of distortion in beam path, which could cause superimposition of the beams and formation of standing waves.

The construction must be carried out in such a way that the area of obstacles to radio waves would be minimum. This is achieved by reducing the maximum building height, by situating structures with their long side parallel to the direction of radio waves, and by increasing the gap between buildings by a minimum of up to three building heights.

Considering the good radio wave reflecting properties of reinforced concrete, this should be considered the best material for shielding structures of buildings planned for a zone of limited construction. Housing would best be oriented with the side having the least window area toward the radiation source. This effect is maximum when the windowless end of the building is oriented toward the source.

Administrative and public buildings should be positioned within the first belt of construction adjacent to the boundary of the strictly controlled zone as a continuous shielding barrier.

The zone of limited construction should contain five-story buildings predominantly. Under such conditions the housing and population densities should be computed according to the lower limit of the standard.

Protective territorial zonation should be foreseen when planning a residential region or microregion: The public center and the microregion's park and the zone of municipal institutions, garages, and parking lots should be positioned at the boundary of the strictly controlled zone; housing should be located in the central area, and children's institutions, schools, and athletic complexes should be located on the periphery. Open areas for games, relaxation, and sports should be located in "radio shadows" formed by buildings, the topography, and green belts.

HYGIENIC ASPECTS OF USING RADIOTECHNICAL DEVICES IN EDUCATION, T. V. Kalyada and V. N. Nikitina, Leningrad, pp 84-85

The problems of organizing education are gaining more and more attention from hygienists since the great mental stress associated with the intensity of the educational program imposes high demands on the health of future specialists. Moreover, while undergoing training, students of institutes and tekhnikums and academy cadets may be subjected to unfavorable environmental factors, including electromagnetic radiation in the radio wave range.

We conducted research to produce hygienic assessments of radiotechnical devices working in different frequency bands and used in school laboratories and at practice ranges of institutions of higher education, tekhnikums, and

merchant marine academies. The measurements showed that the most unfavorable conditions are created when radio technical devices are used in VUZ's. For example when various types of jobs are carried out with SHF devices (replacement of SHF components in generator circuits at the time when they are being tested, work with exposed waveguide channels, mockups, and so on), the density of the power flux of emitted energy is dozens of $\mu w/cm^2$ at different ranges and levels. Irradiation is predominantly local. The greatest radiation intensities were measured when the polar diagrams of antennas were recorded. In this case irradiation was general. However, as a rule the field is nonuniform and the largest values were measured at head level. The power flux density was hundreds and, in some cases, thousands of $\mu w/cm^2$. It should be noted that as a rule the number of radio technical devices in laboratories located in relatively small areas is very high. Therefore when several devices work simultaneously, especially with directed radiation, conditions that are unfavorable from a hygienic standpoint are created for the students.

Cadets of merchant marine academies may be subjected to radiation on the order of dozens of $\mu w/cm^2$ when studying the electronic equipment of seagoing vessels, for example in laboratory work involving determination of the coefficients of traveling and standing waves. The intensity of shortwave and medium-frequency-wave radiation produced by Volkhov, Il'men', and R-641 radio transmitters was from units to tens of volts/meter at different ranges depending on the power and design features of the transmitters.

The intensity was a few volts/meter in radio technical tekhnikums in work involving measuring the depth of modulation, transmitter tuning, tuning circuits in resonance, and in other laboratory operations.

It should be noted that radio technical devices that are being introduced extensively into new industrial processes and which employ the energy of radio frequencies are the objects of study in training institutions preparing specialists for such industrial sectors as footwear, food, haberdashery, and so on.

Thus the research data permitted us to gain an impression of the distribution of radio radiation sources in different training institutions and on the distribution of radiation intensity in school buildings depending on the nature of the work being done, the design concepts behind circuits, the power of radio technical devices, and so on. These data also permitted us to reveal that during training, students are periodically subjected to the effects of radio-frequency electromagnetic fields of sufficiently high intensity. Inasmuch as radio-frequency radiation is viewed as a hygienic occupational factor in the production environment and the young body is so sensitive to unfavorable external conditions, there are grounds for raising the issue of conducting hygienic research so as to develop a program of recommendations by which to improve the conditions under which students must work with radio technical devices.

THE ISSUE OF LABOR HYGIENE AND MAINTENANCE OF HIGH-FREQUENCY FACILITIES IN ELECTRONIC INDUSTRY, Ye. L. Kulikovskaya, Leningrad, pp 85-86

Significant changes have occurred in recent years in the procedures for heating and evacuating electronic instruments. Special semiautomatic evacuating machines have been created, some parts of the getter flash process and other operations have been automated, some processes have been moved into separate shielded buildings, remote control is being introduced, and so on.

However, despite the procedural improvements a large number of HF devices employing induction heating are operated without the appropriate protection, shielding is absent from not only the working parts but also other HF components of generator circuits, and sometimes enterprises themselves install HF generators, resulting in abnormal operation of the device as a whole.

This paper gives the results of examination of the working conditions of personnel servicing semiautomatic machines. It was established that semiautomatic machines not equipped with so-called interference shields, form an HF field at working places that exceeds the standard field by many times.

Semiautomatic machines outfitted with interference fields do not satisfy the requirements either due to imperfections in design and improper use.

Lines for transmitting HF energy to the induction unit are frequently designed in the form of exposed metallic busbars, about which an electromagnetic field with an electric intensity of thousands and more watts/meter and magnetic intensity of dozens of amps/meter is formed.

Personnel servicing some semiautomatic machines outfitted with or not having interference shields experience radiation totaling 200 volts-meters and 16 amps-meters in the first case and 330 volts-meters and 40 amps-meters in the second.

At the same time, research on working conditions of laborers on the flow line of a 100-position semiautomatic VTYe-2 evacuating machine produced by the Hungarian Tungsram Company (Budapest) demonstrated that the conditions were relatively favorable.

The heating method employing high-frequency currents, which exists only in electronic industry, is totally impermissible. In such a case maintenance personnel are in direct contact with practically exposed current-carrying busbars and a working induction unit. The field intensity in the working zone reaches hundreds of volts/meters with respect to the electric component and dozens of amps/meters with respect to the magnetic component.

Our work served as the basis for proposing the "recommendations for reducing radio wave irradiation when working with induction heating devices in electronic industry." The recommendations cover HF induction heating devices used in electronic industry presently being designed, undergoing manufacture, and in actual operation.

SOME CRITICAL REMARKS ON MODERN TECHNIQUES FOR MEASURING ELECTROMAGNETIC FIELDS FOR THE PURPOSES OF THE HYGIENIC SERVICE, I. Musil and K. Marga, Prague, CSSR, pp 86-87

This report examines some of the basic and special problems of measuring and assessing the levels of electromagnetic fields in hygienic practice.

Attention is devoted to typical shortcomings in measuring instruments presently being used, which should only be considered as displays. A critical analysis is made of modern trends in improving these devices, the inseparability of technical and biological approaches is emphasized, and attention is turned to difficulties connected with this problem.

The correctness of this opinion is supported by norms reflecting differences in the basic measuring methods.

The importance of selecting measurement principles is emphasized in the report.

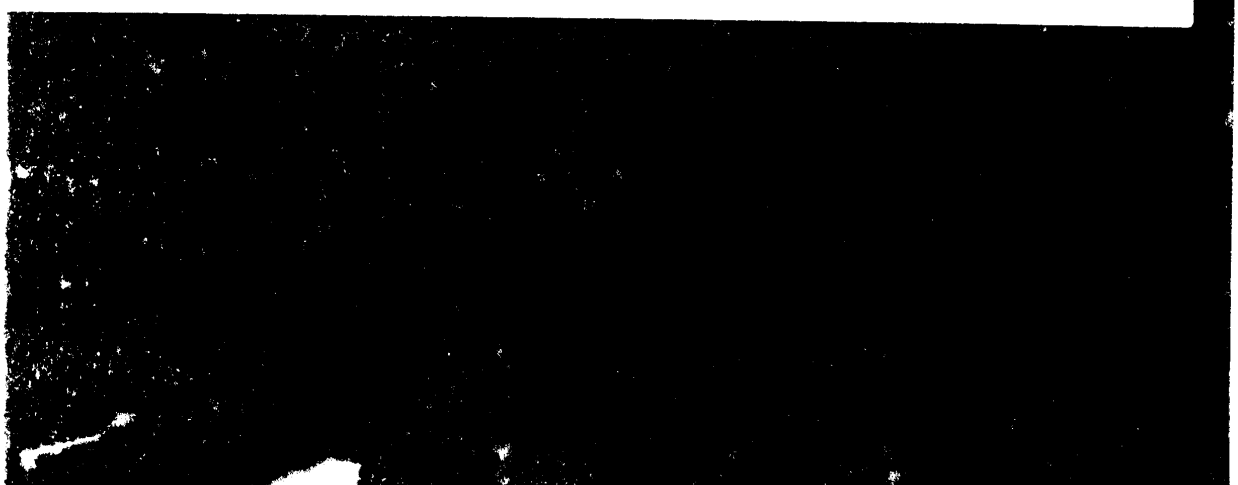
The report concludes with some practical suggestions.

DOSIMETRY OF ROENTGEN RADIATION IN THE PRESENCE OF RADIO-FREQUENCY ELECTROMAGNETIC FIELDS, A. I. Bekel'nyy, M. I. Arsayev, A. V. Silin, and V. A. Krasnikov, Leningrad, pp 87-88

The extensive use of high-voltage electronic instruments, which are sources of unutilized roentgen radiation (kenotrons, thyratrons, modulating and oscillating tubes, klystrons, and so on), makes it necessary to measure roentgen radiation in the presence of electromagnetic fields having different frequencies and intensities. Such electromagnetic fields can have an effect on dosimeters possessing an amplification circuit. Because specific data on the effect of interference on dosimetric instruments are absent in the literature, performance of such measurements would be useful.

The effect of electromagnetic interference in the 1-10,000 MHz range on operation of extensively employed microroentgenometers with scintillation counters -- the Kura, Argun', and Araks, and the MRM-2 microroentgenometer was studied.

The research demonstrated that electromagnetic fields in the frequency range employed caused stable changes in the readings of the MRM-2 and the Kura, even when the field intensity is very low. Electromagnetic interference generally causes reduction of the actual dosimeter readings. Electromagnetic fields have their greatest effect on the instrument panel, and less of an effect on power circuits, on connecting cables, and on the detecting block. The sensitivity of dosimeters is especially high in relation to particular frequencies typical of the given instrument. It was established that 24, 210, 330, 360, and 400 MHz are such frequencies in regard to the MRM-2 microroentgenometer, and 2.5, 24.5, 29, 200, and 420 MHz are such frequencies for the Kura.



Dosimeter reading errors were observed to be over 20 percent when the intensity of electromagnetic fields of the indicated frequencies did not exceed 0.01-01 of the maximum permissible intensity of the MRM-2, and 0.1-1 of the maximum permissible intensity for the Kura.

Use of radiation-resistant fabric containing microconductors as protection of dosimeters from electromagnetic fields results, in most cases, in a sharp reduction in sensitivity of the instruments to electromagnetic interference.

A check of the effect of electromagnetic fields on the Argun' and Araks dosimeters showed that electromagnetic fields in the 1-10,000 MHz range do not affect these dosimeters when the intensities exceed the maximum permissible intensity by at least one order of magnitude.

THE PROCEDURES FOR MEASURING THE INTENSITY OF A FIELD'S MAGNETIC COMPONENT IN THE METER-WAVE RANGE, N. V. Maksimenko, N. N. Goncharova, V. B. Karamyshev, and A. S. Teslenko, Khar'kov, pp 88-89

When the equipment of radio and television transmitting stations is operating, maintenance personnel are subjected to the action of the electric and magnetic components of an electromagnetic field (EMF).

Due to the difficulties in taking account of the quantity and nature of radiation, the distance to the measuring point, and other factors, there is a certain amount of difficulty in analytically determining the expected EMF intensity at the working place. Therefore the intensity of electromagnetic radiation experienced by workers must be assessed according to real measurements of the intensity of electric and magnetic fields.

However, the industrially produced IEMP-1 instrument can measure only the electric component of the field in this frequency range.

Considering the above, the task was posed of developing an instrument to measure the intensity of the field's magnetic component in the 48-100 MHz range.

A loop antenna consisting of one or several windings of a conductor connected to a voltmeter is the simplest indicator of an alternating magnetic field, as compared to sensors employing the Hall and Pikus [transliteration] effect. By calibrating the windings using a standard field source, we get the required instrument.

From our point of view the most efficient solution to the posed task is to build a loop sensing antenna for the IEMP-1 instrument, which is used extensively by public health and labor protection agencies. It should be noted that both resonant and nonresonant sensors can be used to measure field intensity.

As a result of the research we conducted, a resonant sensing antenna was designed. Structurally it consists of a single-winding symmetrical loop with an electrostatic shield and a variable capacitor, high-frequency and constant voltage dividers, and a parallel detector.

The sensor circuit parameters are selected in such a way that they would permit measurement of the magnetic component of the field from 0.1 to 2 amps/meter in the 48-100 MHz range. When fields of greater intensity must be measured, the loop winding dimensions and the parameters of the voltage dividers must be changed.

The voltage at the sensor output was computed depending on field intensity and frequency and subsequently calibrated with a cavity resonator. The disagreement between computed and experimental data does not exceed 20-24 percent.

When measurements are to be made the antenna is situated in the field, tuned to the resonance frequency, and oriented in space such that the readings of the recording instrument are maximum. Then the magnetic field intensity at the given point is determined by the instrument readings and calibration curves.

The procedure we developed for measuring the intensity of a field's magnetic component was tested under production conditions while assessing the working conditions of maintenance personnel at a number of television centers.

THE DRGZ-02 AND DRGZ-03 (ARGUN') SCINTILLATION DOSIMETERS FOR MEASURING INTENSITY OF EXPOSURE TO A ROENTGEN- OR GAMMA-RADIATION DOSE, M. I. Arsayev, V. A. Drasnikov, B. C. Margulis, Moscow, pp 89-90

The advantages of scintillation dosimetry over traditional methods based on measuring ionization of a gas were examined in connection with development of roentgen- and gamma-radiation dosimeters. It was shown that highly sensitive dosimeters having a small detector (about 20 cm^2), which is extremely important in regard to a number of problems of both dosimetry and protection, can be designed. The method permits us to design dosimeters with significantly simplified electric circuits, thus insuring a higher life, good reliability, and unsusceptability to various types of electromagnetic interference and weather and mechanical effects.

Two modifications of the worn Argun's dosimeter (DRGZ-01 and DRGZ-02 [sic]) are presently in series production.

The dosimeters are designed to measure roentgen- and gamma-radiation within a broad range of dose intensities (from 0.01 to 1,000 pr/sec) and energy quanta (from 20 to 3,000 kev).

The possibility was examined for measuring the average intensity of exposure to pulsed radiation, and it was demonstrated that these dosimeters

can measure the average intensity of a dose of pulsed radiation when the pulsed train frequency is over 10 Hz and the pulse duration is over 10^{-6} sec.

MAXIMUM PERMISSIBLE VALUES OF ELECTROMAGNETIC WAVE IRRADIATION EFFECTIVE IN CZECHOSLOVAKIA, K. Marga and I. Musil, Prague, CSSR, p 90

The first national norms were first adopted in the CSSR in 1965.

These norms were reviewed in 1970 on the basis of practical experience gained through clinical and hygienic research. This reports presents the maximum permissible irradiation level in the HF and SHF ranges adopted presently by the CSSR.

The report cites some results of research on working places outfitted with high-frequency industrial generators of many types and purposes.

The worst working conditions were found in woodworking industry and at some electrotechnical plants. In most of the other cases the generators comply with the maximum permissible values of field intensity. This is highly favorable in view of the large number of people that must service high-frequency facilities.

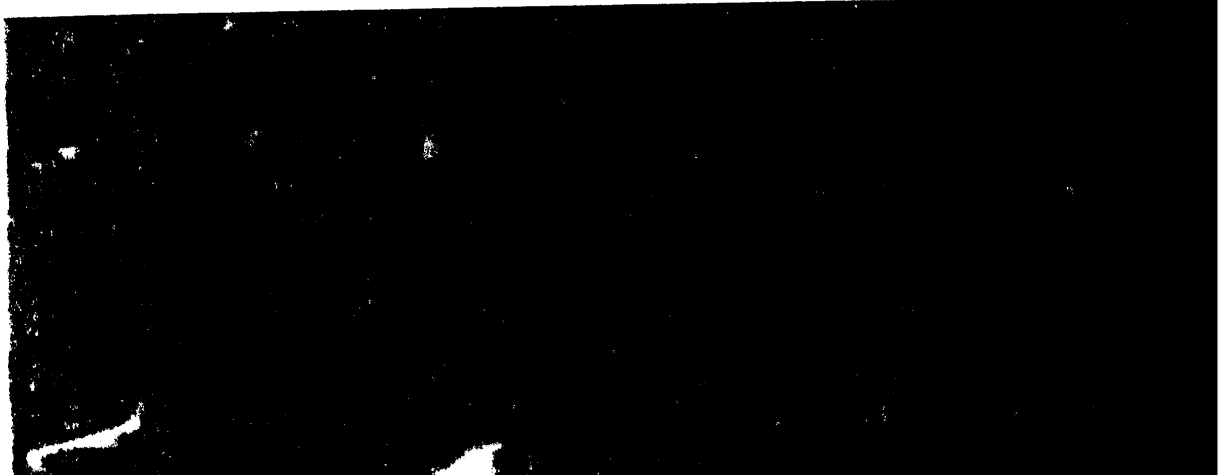
QUANTITATIVE DEPENDENCE OF BIOLOGICAL EFFECTS OF AN SHF FIELD ON POWER FLUX DENSITY AND EXPOSURE TIME, B. M. Savin, A. G. Subbota, B. A. Chukhlovin, V. A. Syngayevskaya, V. A. Zhuravlev, and Z. P. Svetlova, Leningrad, pp 90-91

The present research was devoted to clarifying the energy dependence (the product of the PFD [power flux density] and time) of biological effects arising in response to SHF radiation.

Research conducted on animals (dogs and rats) established the features of body reactions to 10 cm waves with identical incident energy (W) or discrete multiples thereof but respectively differing in PFD (P) and exposure time (t).

The relative biological effectiveness (RBE) of different modes of SHF radiation was determined from a number of clinical physiological indices (motor and secretory conditioned reflexes, arterial pressure, blood potassium, sodium, and glucocorticoid concentration, the leucocyte formula, glycogen concentration, peroxidase activity, the absorptive function of leucocytes, and glucose absorption by an isolated intestine according to the Tiri [transliteration] method for dogs, and change in body weight, peripheral blood composition, muscular endurance, reproductive function, and some pathomorphological indices for rats).

In the first series of experiments we studied the effect of electromagnetic fields having a PFD equal to 5 mw/cm^2 and an exposure time of 60 minutes.



The observed changes were used in subsequent series as a functional standard to which changes arising in response to other exposure conditions were compared.

It was established that when the incident energy remains constant, the biological effect becomes more intense with an increase in PFD.

Experimental data were used to compute the empirical coefficient of nonlinearity of the biological effect in response to SHF fields having different PFD.

Despite the significant differences in radiosensitivity of dogs and rats, the coefficient value (K) is extremely close for both animals, being:

for	PFD	from	1 to 5 mw/cm^2	- 1.3
"	"	"	5 to 10 "	- 2
"	"	"	10 to 25 "	- 3
"	"	"	25 to 50 "	- 4 and so on.

Apparently the established features of body responses reflect a general biological law of nonlinearity in the effects upon change in intensity and time of exposure, which can be expressed by the formula

$$t = \frac{W}{KP},$$

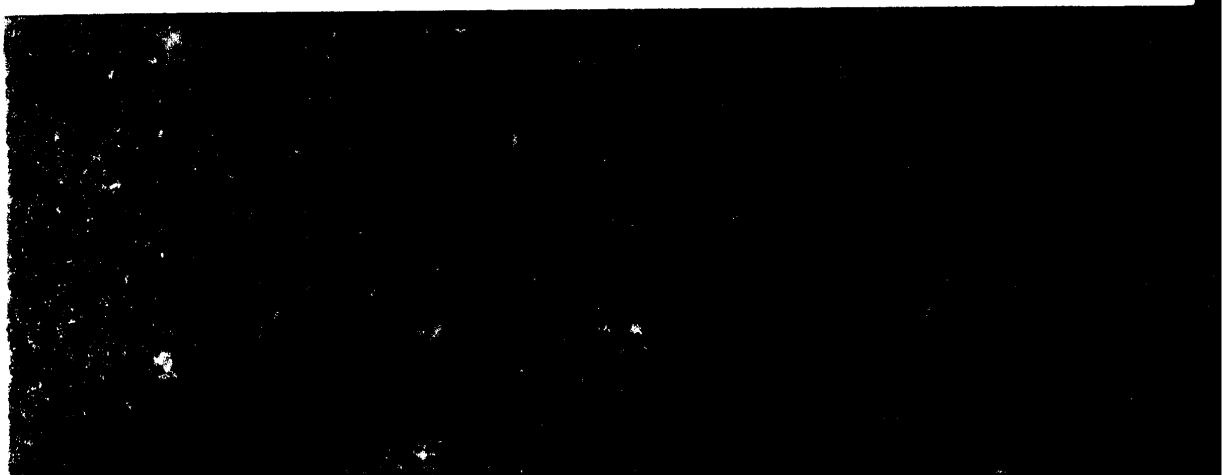
where t is the exposure time, W is the amount of incident energy, K is the coefficient of nonlinearity, and P is the power flux density in mw/cm^2.

RESULTS OF INTEGRATED RESEARCH ON PROBLEMS OF LABOR HYGIENE AND OF THE BIOLOGICAL ACTION OF LONGWAVE ELECTROMAGNETIC FIELDS, N. N. Goncharova, Khar'kov, pp 91-93

The institute has conducted integrated research on working conditions and the effect of longwave electromagnetic fields (EMF) on the body over a period of a number of years.

This research was promoted by the extensive use of high-frequency (HF) devices in industry (for heat processing of materials) and by the small amount of information available on the biological action of EMF in the indicated range. Research was conducted in three directions -- hygienic, clinical-physiological, and experimental.

Research conducted under production conditions demonstrated that equipment (HF devices of various types) being used is inadequately shielded and emits EMF of significant intensity in production buildings (35-250 volts/meter for the electric component and 10-120 amps/meter for the magnetic component). These EMF intensities depend on the design features of the equipment, its power, the extent of shielding, and the distance from the working places to the radiation sources.



Clinical-physiological data accumulated in the last 2 years through physiological, electrophysiological, and biochemical research indicate that longwave EMF have an unfavorable effect on the worker's body. Mildly pronounced functional changes were discovered among examined individuals in a number of the body's systems and, chiefly, in the state of the nervous system. These changes fit the neurasthenic syndrome or autonomic vascular dystonia. Disturbances were also noted in sexual activity (the principal problem being accelerated ejaculation during sexual intercourse), in the cardiovascular and digestive systems (sensitive cardioneurosis, functional diseases of the stomach), and in organs of vision (disturbances of intraocular tension).

Experimental research produced a great deal of multifaceted information. Integrated experimental studies on animals (physiological, biochemical, morphological) revealed the biological activity of longwave (70 kHz) EMF of different intensities and exposure times. The principal manifestations of this action are: A certain rise in arterial pressure, elongation of the latent time of the defensive conditioned reflex, indicating reduced excitability of the central nervous system, change in carbohydrate, nitrogen, and nucleic acid metabolism in the brain, kidney, and liver tissues of experimental animals, associated with a reduction in activity of oxidative processes and impairment of systems that eliminate surplus ammonium ions in nervous tissue.

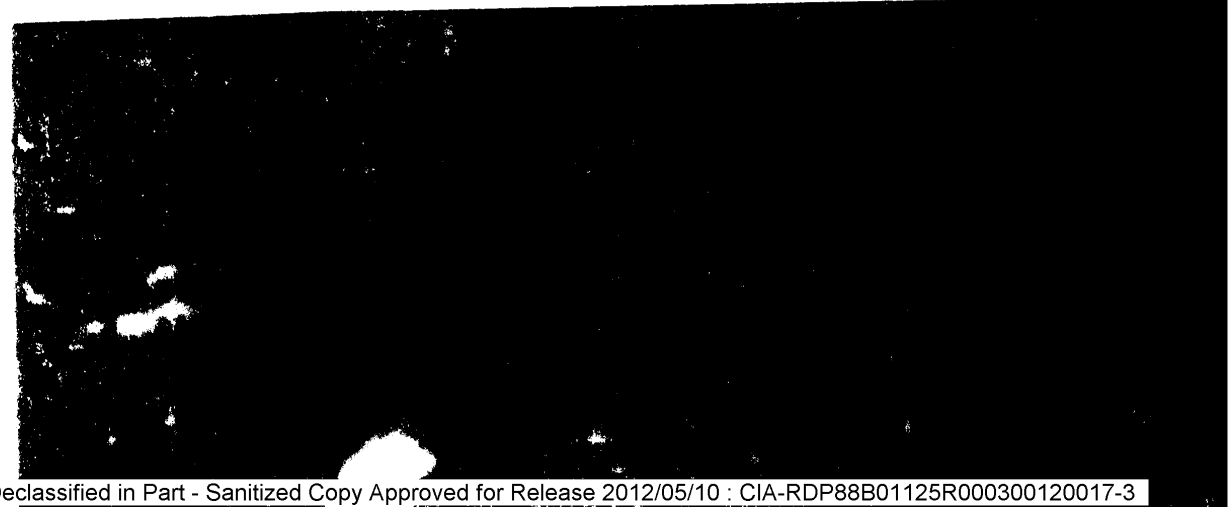
We revealed a dependence of the produced changes on the duration and intensity of exposure and, to some degree, on the particular field component and the specific features of the tissue examined.

The data indicate that measures must be enacted to provide protection against electromagnetic irradiation, and that standards must be established for longwave (60-100 kHz) EMF.

BIOLOGICAL EFFECT OF LOW-INTENSITY ULTRASHORT-WAVE, SHORTWAVE, AND MEDIUM-FREQUENCY WAVE RADIATION IN LABORATORY EXPERIMENTS, P. P. Fukalova, M. S. Bychkov, M. S. Tolgskaya, I. A. Kitsovskaya, A. P. Volkova, N. K. Demokilova, and R. S. Vorontsov, Moscow, pp 93-94

The effect of ultrashort-wave, shortwave, and medium-frequency wave low-intensity electromagnetic radiation on particular systems and organs was studied in chronic experiments on animals (rats, mice, rabbits) lasting 5-8 months: Blood pressure and vascular permeability, the functional state of the nervous system (using EEG and neuromuscular excitation threshold methods), weight dynamics and physical endurance, immunobiological reactivity, and particular indices describing the state of the hypothalamus - hypophysis - adrenal cortex system and protein and mineral metabolism. Morphological research was also conducted.

Either total absence of a biological effect (with respect to weight dynamics, the threshold of neuromuscular excitation, vascular permeability) or only



a tendency toward change in functional state (in regard to endurance, pressure, immunobiological reactivity) was observed in response to ultrashort-wave radiation (69.7, 155, and 191 MHz).

Morphological research indicated that while there were absolutely no changes in the nervous system, insignificant changes were all that occurred in internal organs -- nonuniform coloration of myocardial fibers, swelling of individual skin receptors and internal organs, and weakly pronounced reproduction of histocytic elements in the liver and spleen and of lymphoid elements in the lungs.

No changes were noted in response to shortwave electromagnetic fields (14 and 88 MHz) in the indices for weight dynamics, blood pressure, vascular permeability, immunobiological reactivity, the neuromuscular excitation threshold, and the concentration of epinephrene and norepinephrene. Changes in some indices for protein and mineral metabolism and in the hypothalamus - hypophysis - adrenal cortex system were noted in only some periods of irradiation. Morphological research revealed weakly pronounced changes in the nervous system and internal organs.

Experimental research on the biological action of a medium-frequency wave electromagnetic field (500 kHz) did not reveal any sort of changes in the studied indices.

The biological effects of ultrashort-wave, shortwave, and medium-frequency wave radiation were also studied in an acute experiment by electroencephalography with the purpose of establishing the minimum intensities causing changes in the EEG. The thresholds of initial reactions of the brain based on total bioelectric activity were established for these ranges.

The research data have been used as a standard-setting basis.

BIOLOGICAL EFFECT OF LOW-INTENSITY 150 MHZ RADIO WAVES, T. V. Kalyada, V. N. Nikitina, and N. T. Sverdlina, Leningrad, pp 94-95

Research on the biological action of low-intensity ultrashort-wave electromagnetic waves (with frequency over 100 MHz) has been highly inadequate, though theoretical computations and concepts indicate that this portion of the spectrum may have high biological activity. For example, it follows from V. A. Franke's computations (1963) that resonant power absorption maximums produced due to equality of body lengths and wavelengths, are possible in the meter-wave range. The penetrating depth and selectivity of energy absorption in different frequency ranges are of undoubtable significance. Both qualitative indices of physiological reactions and the degree to which they are pronounced are associated with these factors (Shlipkhake, 1933).

We studied the general action of 150 MHz continuous nonthermogenetic-intensity ultrashort-wave radiation. Research was conducted on practically

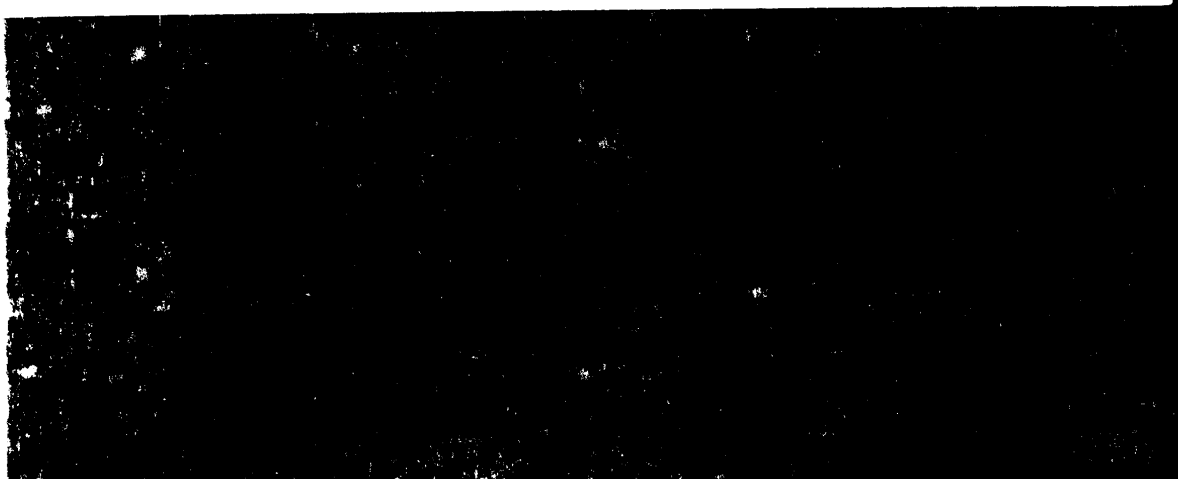
healthy intact individuals under experimental conditions. The time of observation over simulated (control) and actual irradiation was 25-30 days. Daily exposure was 30 minutes. Two series of experiments were conducted. The intensity of the electromagnetic field at the test subject's location was 7-16 volts/meter in the first series and 3-5 volts/meter in the second. The research revealed deviations in skin temperature reaction and changes in the threshold of temperature sensitivity to heat stimuli. A significant decrease was noted in the number of active heat receptors during irradiation. Termination of the stimulus caused the reaction to deepen. Irradiation also caused some changes in electric excitability of the visual analyzer. These changes were not significant under experimental conditions. The absolute value of the excitability coefficient (Yu. M. Uflyand, 1938) changes significantly throughout the entire time of irradiation. Research on the state of the cardiovascular system reveals a tendency toward reduction of maximum and pulse pressure during irradiation. However, during the entire time of irradiation the initial values of these indices were higher than in simulated exposure, indicating that the stimulating action of the field on the sympathetic nervous system has a cumulative effect.

Research on regional circulation revealed deviations in some indices describing the function of peripheral vessels. An analysis of plethysmograms demonstrated change in the reactivity of peripheral vessels both during irradiation and in the postradiation period. Deviations in pulse and modulus of elasticity indicated that regional vessels have a phasic response. In both series of experiments we noted a significantly larger percentage of vasodilatory reaction at the moment the generator was switched off. This agrees with data on skin temperature. Further irradiation produced spasms. The same sequence of phases was also revealed in the recovery period. In both series we noted accumulation of functional changes expressed in restructuring of indices describing the state of peripheral circulation, indicating heightened vessel resistance. Hypertension revealed among workers exposed to EMF having the same parameters (R. N. Vol'fovskaya, T. P. Asanova, et al., 1968) confirms that the biological effects revealed in the experiments may be cumulative.

Such a change in the level of functional activity can be interpreted as an adaptive reaction only in the initial stage of the factor's action inasmuch as clinical data indicate that functions do experience profound disturbances and that according to some indices pathology develops when a low-intensity stimulus has a prolonged effect.

THE HYGIENIC SIGNIFICANCE OF RADIO-FREQUENCY ELECTROMAGNETIC FIELDS IN POPULATED AREAS, AND SETTING STANDARDS FOR SUCH FIELDS, M. G. Shandala, Yu. D. Dumanskiy, Kiev, pp 95-97

The problem of hygienically assessing and setting standards for radio-frequency electromagnetic fields in populated areas has acquired important significance today in connection with expansion of the network of radio



transmitting stations, construction of major television centers and relay stations, and operation of continually more powerful radar stations.

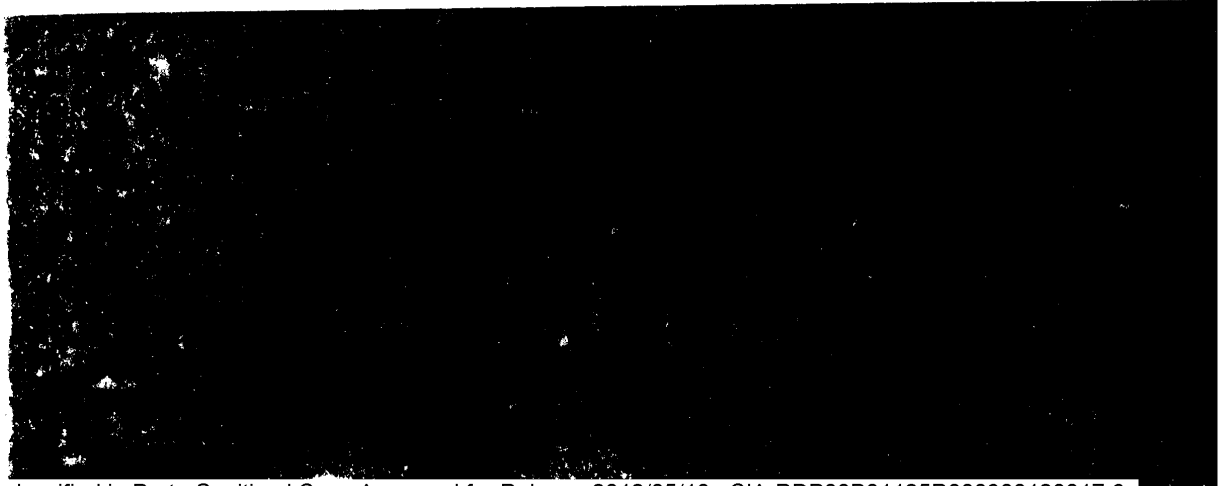
Research conducted from the aspect of municipal hygiene demonstrated that in some residential areas in which radio transmitting facilities are located, the electromagnetic field intensity fluctuates within broad limits in the shortwave, ultrashort-wave, and microwave bands depending on the power of the transmitter and the distance to the antennas. Under such circumstances, in a number of cases electromagnetic waves penetrate into residential, public, and other buildings located near radio transmitting facilities.

In addition we conducted experiments on animals, which demonstrated that unfavorable changes occur in the nervous, cardiovascular, and endocrine systems in response to chronic exposure to shortwave (50-4 volts/meter), ultrashort-wave (6-1 volt-meters), and ultrashort-wave (20-5 $\mu w/cm^2$) electromagnetic fields. Consequently the results of this research indicate that this factor is subject to hygienic standards in populated areas.

On examining the problem of setting standards for intensity of radio-frequency electromagnetic fields, we came to feel that there should be different maximum permissible limits for industrial zones and populated areas, and that mechanical transfer of standards from one area to the other would be impermissible. The reason for this is that adult and practically healthy individuals are exposed to radio-frequency electromagnetic fields in industrial zones for a relatively short time (5-6 hours per shift), while in populated areas this factor prevails for 12-20 hours, and sometimes around the clock. Moreover, not only adults and healthy individuals but also children, the elderly, and patients are affected. The bodies of these individuals are more sensitive to harmful environmental factors. Thus we can assert that the field intensity in populated areas should be lower than that in industrial areas.

When working out maximum permissible electromagnetic field levels for populated areas, we should devote special attention to integrated biological research, which should be related to the existing intensities of electromagnetic fields. We should devote our principal attention to selecting tests that would describe the entire nervous system, the endocrine system, and blood.

Experimental research on animals should obviously be the mandatory and principal data-collecting method in setting standards on low-intensity electromagnetic fields effective over a long period of time. Not only pathological but also functional changes arising in the bodies of man and animals in response to this factor must be the criteria of the biological action of electromagnetic fields, to be used in standard-setting for municipal hygiene. Thus it is obvious that the subthreshold level that does not evoke any sort of functional changes in the bodies of man and animals would properly be adopted as the maximum permissible level of electromagnetic energy in populated areas.



Considering, in addition to this, that not all of the population of populated areas is exposed uniformally to electromagnetic fields throughout the day, and that children, patients, and the elderly are more sensitive to this factor, it would be a good idea to differentiate the standards for this factor. In other words separate standards should be set for 1) open territory, 2) residential buildings, 3) children's institutions, and 4) hospitals, sanatariums, and health resorts.

In light of this information and on the basis of our experiments, we feel that we can recommend 0.5 volts/meter as the maximum permissible intensity of shortwave electromagnetic energy, 0.2 volts/meter for ultrashort-wave energy, and 0.5 $\mu w/cm^2$ for superhigh-frequency electromagnetic energy.

FEATURES OF THE ACTION OF LOW-FREQUENCY PULSED ELECTROMAGNETIC WAVES (PEMF) ON THE BODY, G. I. Yevtushenko, F. A. Kolodub, I. S. Ostrovskaya, L. N. Yashina, V. V. Tkachenko, V. M. Abashin, and I. N. Sinitsa, Khar'kov, pp 97-99

Thorough research on the biological action of low-frequency (7 kHz) PEMF of different intensities (0.4-72 kmps/meter) indicates that the action of such fields is polytropic.

It was demonstrated that reduction in leucocyte number is the most typical change in the morphological pattern of the blood. A pronounced reduction in the neutrophil group of leucocytes is observed in the leucocyte formula coupled with simultaneous increase in lymphocyte concentration. Within the neutrophil group itself, while the concentration of mature forms decreases, other forms of leucocytes as young as myelocytes appear, indicating that a certain degree of "rejuvenation" occurs in the neutrophil nucleus. Under these same conditions the number of active leucocytes drops and their functions involving capture and digestion of bacteria decrease. The lysozyme and agglutinin titers are lower, obviously due to impairment of their synthesis in the liver. According to morphological research, the liver, testes, and the central nervous system are the most vulnerable to PEMF. Changes in these organs occur on a background of a general disturbance of lympho- and hemodynamics having the form of vascular plethora and edemic phenomena. Edema of the stroma, and disintegration and dystrophy of all cell layers of the spermatogenic epithelium are observed in the testes. Upon prolonged exposure (3 and 6 months), to a 24 kamp/meter field the intensity of changes increased continually, leading to evacuation of a significant proportion of seminal tubules, in which lime was deposited, and to sclerosis, progressing as far as complete atrophy of the testes in some animals.

The described changes stemmed from changes in testis metabolism detected in response to PEMF. For example, while a 10-day exposure to a 72 kamp/meter PEMF did not have an effect on the concentration of glucose and pyruvic and lactic acid, or on lactate dehydrogenase activity, it did cause a reduction glycogen and inhibition of cytochrome oxidase activity. Reduction of the

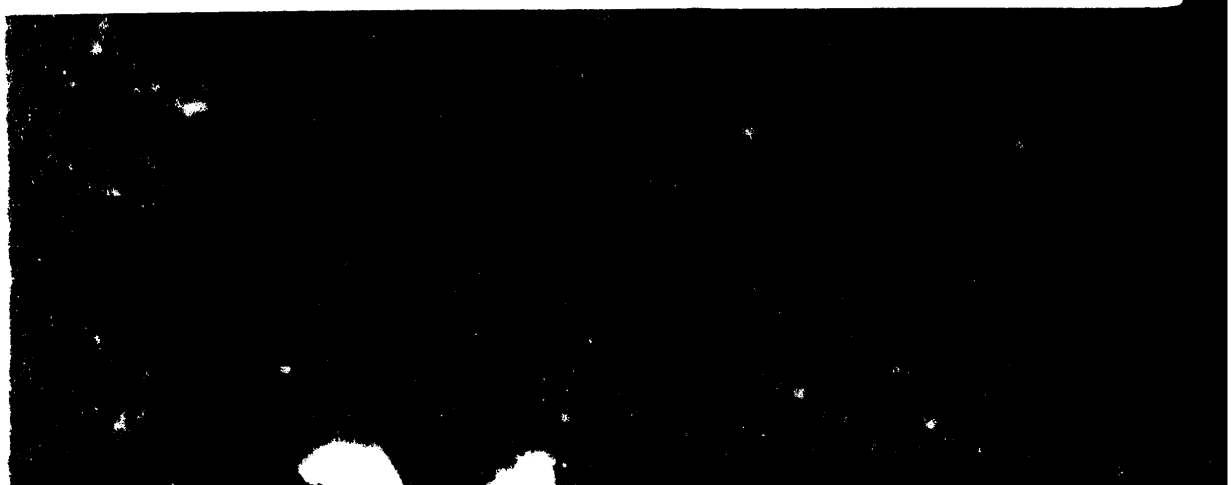
activity of this enzyme indicates that significant deviations in electron transport along the respiratory chain arose in the testis of irradiated rats. This undoubtedly had an effect on the intensity of oxidative phosphorylation and, as a consequence of this, on the level of macroergic compounds (ATP) in them.

Under such conditions ammonium accumulates in the absence of changes in glutamine concentration and in the presence of a reduction of amide nitrogen in proteins and creatine, the role of which in maintaining normal testes structure was persuasively shown by A. M. Aleksyeva (1963). Disturbances in nucleic metabolism play a significant role in structural changes in the testes. RNA and DNA levels decrease in response to PEMF, probably causing disturbances in protein biosynthesis and transmission of genetic information. The decrease itself of nucleic acid concentration is caused by activation of deoxyribonuclease by PEMF.

In the liver, of special interest are the diverse morphological manifestation of dystrophy and necrobiosis of hepatocytes, hydropenic dystrophy being the most widespread and significant. Biochemical and histochemical research indicates that profound metabolic disturbances occur in liver parenchyma, manifested in reduction of the concentration of ATP, glycogen, glucose, ribo- and deoxyrobonucleoproteins, proteins, and SH-SH groups in proteins, and in changes in a number of redox and hydrolytic enzymes. The consequence of the field's effect on the activity of enzymes involved in nitrogen metabolism (glutamine synthetase, AMP-aminohydrolase, RNA-ase, and DNA-ase) was changes in the levels of ammonium, glutamine, glutaminic, ribo-, and deoxyribonucleic acid, urea, and protein amide groups.

A typical feature of the action of PEMF on the body is its ability to increase the level of free radicals in organs and tissues, primarily in the liver, testes, muscles, and brain tissues. At the same time a reduction is observed in all studied organs in total nicotinamide adenine dinucleotide (NAD) concentration due to the reduction of its reduced form. This reduction is associated with inhibition of pyruvate decarboxylation and beta-oxidation of fatty acids in the case of NAD, and with disengagement of oxidatve phosphorylation and an increase in the reduced form of flavoproteins in the case of NADH. Consequently, most probably the increase in free radicals in response to PEMF is caused by intensification of the self-oxidation of fatty acids coupled with beta-oxidation.

Thus it follows from these data that PEMF have an effect on many functional systems of the body, the principal damage being experienced by sex glands, the liver, and the central nervous system. The effect of PEMF on metabolism in the indicated organs and, chiefly, on processes associated with electron transport and flavin participation is the principal mechanism underlying development of pathological changes in these organs.



THE STATE OF MUSCLE WORKING ABILITY, BRAIN ELECTRIC ACTIVITY, AND THE PULSE OF EXPERIMENTAL ANIMALS EXPOSED TO A LOW-FREQUENCY PULSED MAGNETIC FIELD, V. B. Rodkin, Moscow, pp 99-100

Research was conducted with an experimental magnetic device creating constant or pulsed magnetic fields (frequency 10 Hz, pulse duration 0.06 sec) having intensities up to 850 oe within a solenoid.

The biological effectiveness of pulsed and constant magnetic fields of equal intensity turned out to be different: A constant magnetic field caused a rapidly passing rise in static working ability, while on the contrary a pulsed magnetic field caused significant reduction of static working ability that remained stable.

A half-hour exposure to 10 Hz 200, 100, and 50 oe pulsed magnetic fields induced a synchronization reaction in the electroencephalogram of the sensomotor (frontal-parietal) region of a rabbit's head (significant synchronization, $P<0.05$, with an increase in the number of slow waves and spindles).

A similar significant reaction in the electroencephalogram in response to a constant magnetic field was observed only at intensities of 200 and 100 oe. The electroencephalographic reaction to a 25 oe pulsed magnetic field and to a 50 oe constant magnetic field was insignificant ($p>0.05$).

We were able to note changes ($p=0.05$) on the part of cardiac activity in response to a 200 oe pulsed magnetic field. These changes were manifested in slowing down of the pulse and an increase in the duration of the cardiac cycle (of the P-P interval in the electrocardiogram).

A constant magnetic field did not induce such a reaction in cardiac activity.

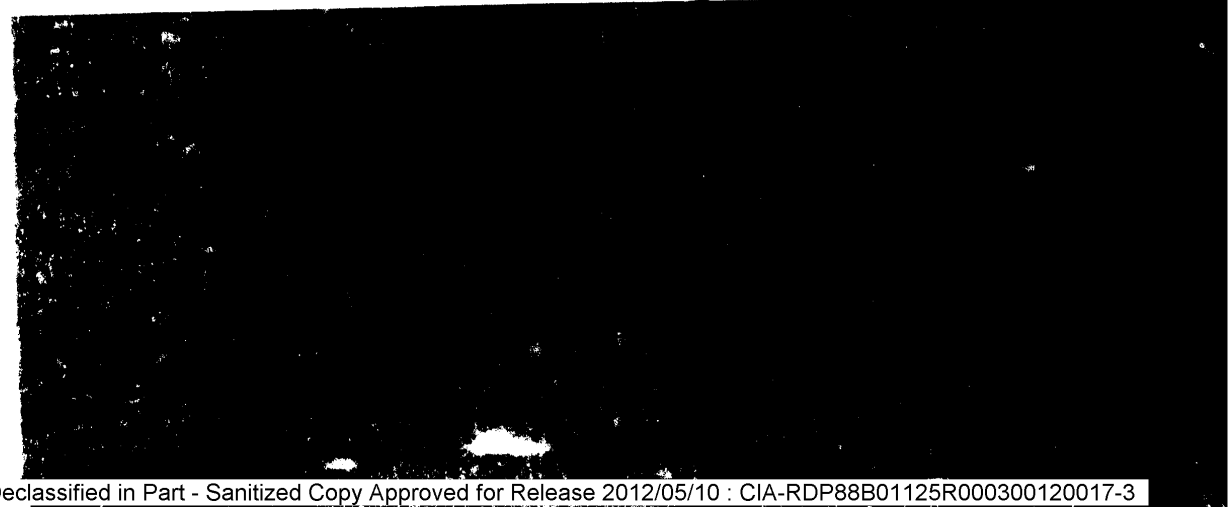
We can consider that a 10 Hz pulsed magnetic field has a more pronounced biological effect on the brain than does a constant magnetic field of identical intensity.

The threshold electroencephalographic reaction to a 10 Hz pulsed magnetic field is within 50 and 25 oe.

WORKING CONDITIONS AND THEIR EFFECT ON THE FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM OF WORKERS AT HIGH-VOLTAGE SUBSTATIONS, N. N. Goncharova, V. B. Karamyshev, N. V. Maksimenko, D. K. Abramovich-Polyakov, V. N. Panova, A. S. Teslenko, and V. V. Tkachenko, Khar'kov, pp 100-101

Hygienic research conducted at exposed 330 kv outdoor distributing systems (ORU-330) demonstrated that the intensity of the electric field at the working places of maintenance personnel is 2.5-17 kv/meter, and that in some cases it reaches 22 kv/meter.

These field intensities are created by high-voltage electrotechnical devices of outdoor distribution systems -- dischargers, busbar switches, air-blast breakers, current and voltages transformers, busbars, and others.



Physiological research performed under production conditions (during the work day) revealed functional changes in the state of the central nervous and cardiovascular systems of workers. These changes were manifested as elongation of the time of optical motor response, a rise in olfactory thresholds, a worsening of memory and attention, and reduced pulse.

Clinical examination of workers in a hospital revealed functional disturbances of the nervous system (particularly of its autonomic divisions). Such examination also permitted integrated study of the functional state of various parts of the cardiovascular system.

Electrocardiography revealed bradycardia and retardation of intracardial throughput (extracardial disturbances of autonomic regulation) in one-third of the subjects.

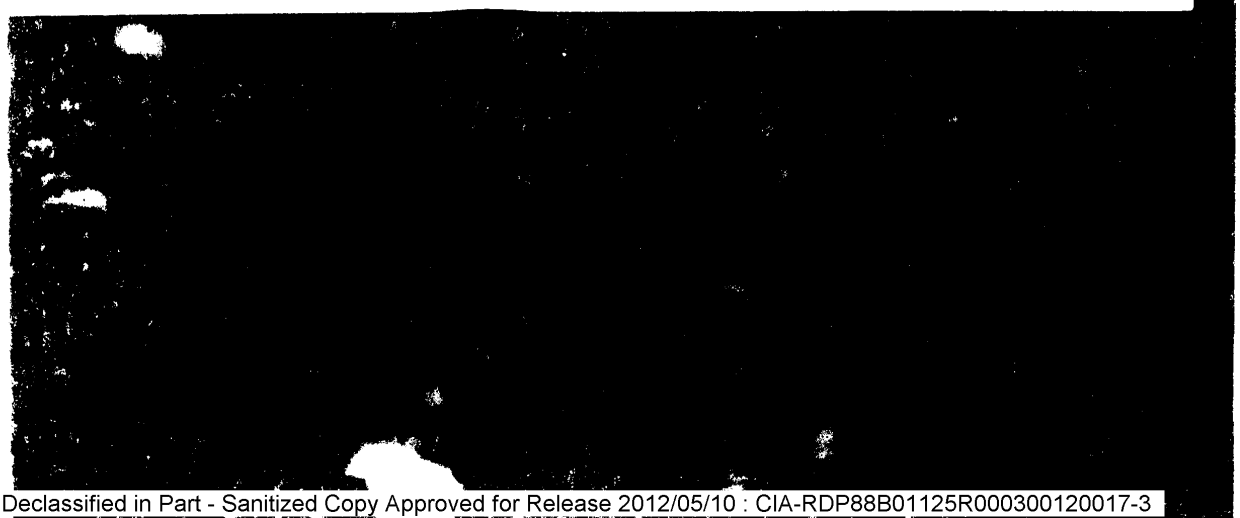
The rate of propagation of a pulse wave indicated that the elastic properties of the medium-diameter muscular arteries increased in two-thirds of the workers. Blood pressure in digital arteries was greater in 56 percent of the subjects, and it was often asymmetrical, indicating reduction of the tone of small-diameter arteries.

Temporal pressure and the temporobrachial coefficient fluctuated extensively, and they were asymmetrical in almost two-thirds of the workers.

A comparison of the tendency for a rise in venous pressure and reduction of blood flow rate in two-thirds of the subjects suggested that venous tone had decreased.

Thus workers involved with the ORU-330 were found to have general vascular dystonia coupled with a tendency toward higher tone of the smallest vessels and medium-diameter arteries, and toward reduction of tone in small-diameter arteries and veins. These vascular changes are probably nonspecific. They can be interpreted as associated with disturbances in autonomic nervous regulation, and they are observed both among individuals having clinically distinguishable disturbances of the nervous system and among practically healthy workers -- that is, the changes are often early and preclinical. The conducted research program on the vascular network and heart is recommended as an extremely complete and adequate program for revealing the unfavorable effects of electromagnetic fields on man.

In order to improve the working conditions of maintenance personnel involved with outdoor distribution systems, we must employ protective resources directed at reducing the electric field intensity at working places by means of local shields.



PRESSING PROBLEMS IN LABOR HYGIENE AND OCCUPATIONAL PATHOLOGY IN THE PRESENCE OF STATIC ELECTRICITY, F. G. Portnov, P. I. Nepomyashchiy, and A. P. Iyerusalimskiy, Riga, pp 101-102

Serious attention has been devoted in recent years to the problems of labor hygiene and occupational pathology in connection with the effects of static electricity. The division of clinical biophysics of the Riga Institute of Mechanical Engineering conducted a series of studies on site at various industrial sectors (textile, woodworking, light, and chemical fiber production). Hygienic research revealed accumulation of static electric charges on production facilities, parts, materials, and maintenance personnel. Static electric fields can reach a significant size on the human body surface in this case -- up to 1,500 kv/meter.

The morbidity of 1,500 workers affected by static electric fields was studied, and 184 workers were subjected to clinical laboratory examination.

A comparison of research results for the experimental and control groups revealed a significant rise in morbidity of individuals working within the effective range of static electric fields (primarily due to diseases of the nervous system and circulatory organs, and acute respiratory diseases).

Functional disturbances of the autonomic nervous system (asymmetry in the temperature and electric resistance of skin, changes in the autonomic index, and in blood cholinergic activity) and in some indices of immunobiological resistance (the blood serum lysozyme level, the skin bactericidal action) were revealed in individuals working for a long time (over 3 years) within the effective range of static electric fields.

The research was used as a basis to work out specific proposals for improving hygienic working conditions, particularly by introducing various sorts of static electricity neutralizers. The experience of operating high-voltage neutralizers in a textile combine demonstrated their hygienic effectiveness. The total morbidity of people working within the effective range of neutralizers was found to be significantly lower than that of a control group.

This communication presents facts illustrating these concepts.

SOME RESULTS OF STUDYING THE EFFECT OF STATIC ELECTRIC FIELDS IN EXPERIMENTS, F. G. Portnov, L. I. Izrailet, P. I. Nepomyashchiy, M. P. Sinel'shchikova, and R. F. Feoktistova, Riga, pp 102-103

This communication presents data from research on the effect of static electric fields of various intensities in acute and chronic experiments conducted by the division of clinical biophysics in 1968-1970.

It was clarified that one-time exposure to a static electric field (E = 60-80 kv/meter) causes a statistically significant rise in rectal

temperature, an increase in the number of reticulocytes, reduction in the number of leucocytes, increase in alanine transaminase, and significant reduction (for 2-4 days) in the concentration of sulfhydril groups in the blood followed by recovery of this index on the sixth day.

A static electric field(E = 180-200 kv/meter) was found to have an effect on higher nervous activity (rate of formation and reinforcement of a conditioned reflex during the period of its development), on the concentration of erythrocyte adenyl nucleotides, alanine transaminase, and sulfhydril groups, on the quantity of leucocytes, on leykergiya [translation unknown], and on acetylcholinesterase activity.

Data indicating pronounced changes in immunobiological reactivity of the body (inhibition of phagocytosis, compensatory increase in the bactericidal capacity of the skin after 15 days, reduction in intensity of oral cavity purification) were obtained in a subacute experiment (45 days) employing a 180-200 kv/meter static electric field.

Prolonged chronic exposure to a static electric field (E = 60-80 kv/meter) leads to changes in the body's immunobiological resistance.

The possible adaptations of the body to the effects of a static electric field are examined in this report.

STANDARD-SETTING INFORMATION FOR STATIC ELECTRICITY IN PRODUCTION, G. A. Antropov, I. I. Rezanov, and A. N. Sergeyev, Moscow, pp 103-104

We studied the effect of 12,000 and 1,000 volt positive static charges.

Research conducted on white rats demonstrated that in response to 12 kv positive static electricity, changes are observed in animal weight and excitability threshold. Changes occur in the sorptive activity of a number of organs with respect to neutral red. Reversible morphological changes were noted in some organs of experimental animals.

Considering that pain is one of the unfavorable factors in the action of static electricity upon discharge, we determined the pain sensitivity thresholds of rats and man.

The pain sensitivity threshold was found to be equal to 2,000±400 volts when static electricity is discharged from the rat, and 1,600±300 volts when it is discharged onto the rat. The human threshold for discharge of static electricity from a charged body to the individual was equal to 1,860±450 volts.

Research conducted with 1,000 volt positive static electricity did not reveal a pronounced unfavorable effect on the rat body. Nor were histomorphological changes established in the internal organs and central nervous system of rats subjected to a 1,000 volt charge.

Consequently 1,000 volts can be adopted as a reference point in establishing the maximum permissible level for positive static electricity.

STATIC ELECTRICITY AS A HYGIENIC PROBLEM IN PRODUCTION AND IN THE USE OF POLYMER MATERIALS IN HOUSING CONSTRUCTION, L. I. Maksimova, I. K. Pushkina, A. Ya. Dyuzheva, N. S. Smirnitskiy, and Zh. S. Kanevskaya, Moscow, pp 104-105

In production, static electricity can accumulate in large quantities on the human body. Published data indicate that static electricity can have a specific action on the living body.

Hygienic and clinical-physiological research was conducted on the effect of static electricity on the bodies of workers producing tires, paper-laminated plastic, and polystyrene film and thread, and of individuals working in sewing enterprises. It was established that the intensities of static electric fields at working places and the voltages of static electricity on the surfaces of articles and the bodies of workers fluctuate within wide limits. Physiological research conducted during the work day indicated reduced resistance of skin to electric current, slower rate of nervous reactions to light and sound, and reduced strength and indurance of hand muscles with respect to static voltage, as compared to controls. Polyclinical examination of 161 individuals revealed changes of a functional nature that boiled down to an asthenic symptom complex coupled with a pronounced neurotic component reaching the intensity of a "phobia" -- a fear of approaching a machine tool in anticipation of discharge and an electric shock. Disturbances were observed in arterial tone and autonomic innervation in the form of unstable arterial pressure (usually a tendency toward hypotonia), bradycardia, and reduction of voltage on the electrocardiogram. Red blood indices had a tendency to rise, erythrocyte hypochromia being present. Electroencephalographic research indicated developed irritation phenomena and intensification of the activating effect of the brain stem's reticular formation. Identical but milder changes were revealed in the health of individuals subjected to static electricity in residential buildings in which floors are covered by polychlorvinyl tiles or linoleum. The charges on the floor surface varied from 100 to 4,000 volts depending on the relative humidity and season of the year. An analysis of visitation rates and temporary incapacitation based on the outpatient charts of regional polyclinics indicated that these indices are significantly larger among residents of houses containing polymer flooring, as compared to controls.

Thus the biological action of static electricity on the human body cannot be doubted. Measures direction at reducing potentials and the intensity of static electric fields in accordance with the "Regulations for Protection Against Static Electricity and Secondary Lightning Manifestations in Industry" were recommended to enterprises. Corrections were made in statements indicating the suitability of the use of a number of polymer construction materials as floor coverings in residential buildings.

RESEARCH ON THE BIOLOGICAL ACTION OF ELECTROSTATIC FIELDS OF DIFFERENT INTENSITIES ON MAN, A. V. Yakubenko, V. V. Lukovkin, T. Ye. Sazonova, and T. I. Krivova, Leningrad, pp 105-106

Little research has been conducted on the action of high-voltage electric fields on people. In this connection the All-Union Institute of Labor Protection conducted a study in 1965-1971 in Leningrad on the effect of constant electric fields of different intensities -- 20, 30, 60, and 90 kv/meter -- on man. The research was conducted under laboratory conditions (and under production conditions for the 20 kv/meter field). A high-voltage device was designed generating a field having a practically uniform intensity at the point where two to four people are located. The 20 kv/meter field corresponded to that measured at head level underneath LEP-800 wires, while the 30 kv/meter field corresponded to the measurement underneath the planned LEP-1500 wires. The 60 kv/meter field corresponded to the greatest field intensity in the vicinity of an isolating switch, while the 90 kv/meter field corresponded to a point in direct proximity to LEP-1500 wires.

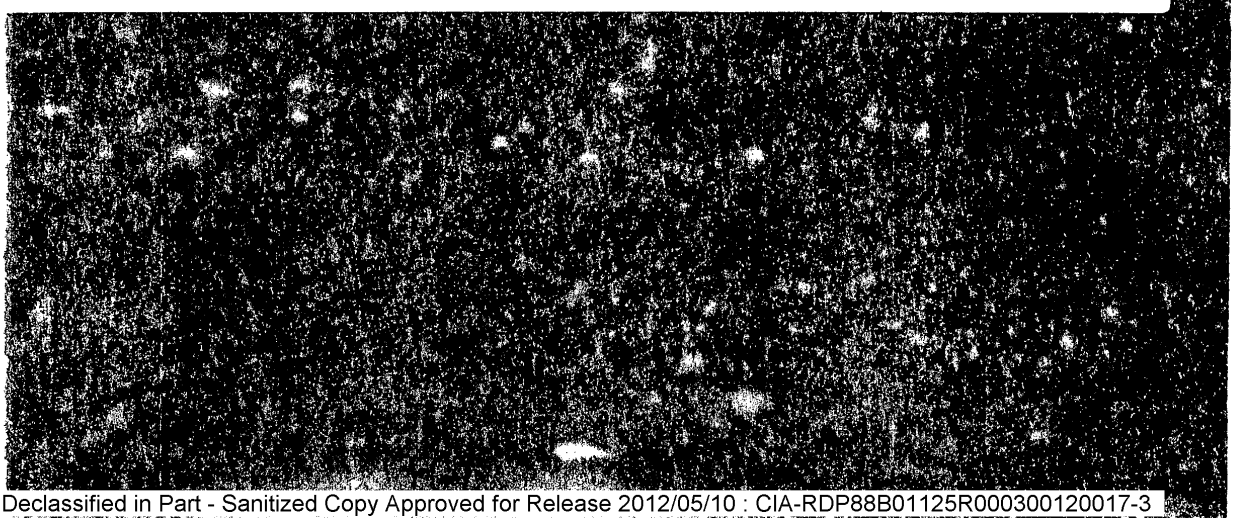
The research was conducted on healthy volunteers -- men from 20 to 30 years old. Changes in higher nervous activity, in functions of the central nervous system and cardiovascular system, in body temperature, and in blood morphology were assessed. Changes occurring during work with an ergograph conducted within 60 and 90 kv/meter fields were studied as well.

Control examinations lasting 10-14 days preceded exposure to the fields. Then for 2 months (for 30 calendar days with respect to 60 and 90 kv/meter fields) the test subjects were subjected to the fields for 2 hours a day. Next the test subjects were examined for another 10-15 days after termination of exposure.

The research did not reveal unfavorable effects of 20 and 30 kv/meter static fields on man.

A significant decrease in maximum arterial pressure (at rest) by 14-16 mm Hg was observed in test subjects after exposure to a 60 kv/meter field. The maximum pressure tended to increase slightly and the minimum pressure tended to decrease slightly after work with the ergograph as compared to the control period. The return of arterial pressure to its initial level after physical work occurred more slowly than in controls. The pulse was noted to decrease immediately after work and upon termination of exposure. The threshold of neuromuscular excitability in response to electric stimulation by pulses of long duration (0.65 and 1.00 meters/sec) decreased. Cumulative changes were observed in the lability of the brain's subcortical functions, as determined by rayvolriskopiya [translation unknown]. These changes were not stable, and functions returned to normal relatively quickly.

Exposure of test subjects to a 90 kv/meter field had an unfavorable effect on the body. Moderately pronounced disturbances in cardiovascular functions



and blood changes were observed. The precision of work done with the ergograph decreased, and the number of unconscious errors increased. Some changes (hypotonia, bradycardia, thrombocytopenia) persisted 5-7 days after termination of exposure.

It is hoped that the results of this research will be used as grounds for hygienic norms for permissible intensities of constant electric fields.

EXPERIMENTAL MODELING OF AN ELECTROSTATIC FIELD IN HYGIENIC RESEARCH ON ELECTROSTATIC CHARGING OF CLOTHING, M. G. Shandala, and V. Ya. Akimenko, Kiev, pp 106-107

The absence of a conclusively recognized theory of polymer electrostatic charging and a theory on the effects of an electric field on the human body makes it difficult to provide a hygienic solution to the problem of polymer electrostatic charging in general and electrostatic charging of clothing in particular.

In view of the low intensity of this factor, it is impossible to determine the degree of its effect and, correspondingly, its hygienic significance without performing experiments. But such experiments would be unimaginable without prior establishment of the laws and quantitative characteristics of electrostatic charging of clothing. With this purpose we developed a special procedural approach permitting establishment of the dependence of the effective intensity of an electric field created by electrostatically charged clothing on the chemical nature of fabric fibers, the cut and integrity of clothing, the mobility and the anatomical and physiological features of the human body, and air temperature and humidity.

Research on 16 samples of clothing representing 48 outfits demonstrated that an individual can be subjected to electrostatic fields of different orientations and intensities (from tenths to several hundred volts per centimeter) which often exceed the natural field of the earth by 1,000 times and more. As the relative humidity increases, the degree to which clothing can become electrostatically charged drops, but this is not always a strict law.

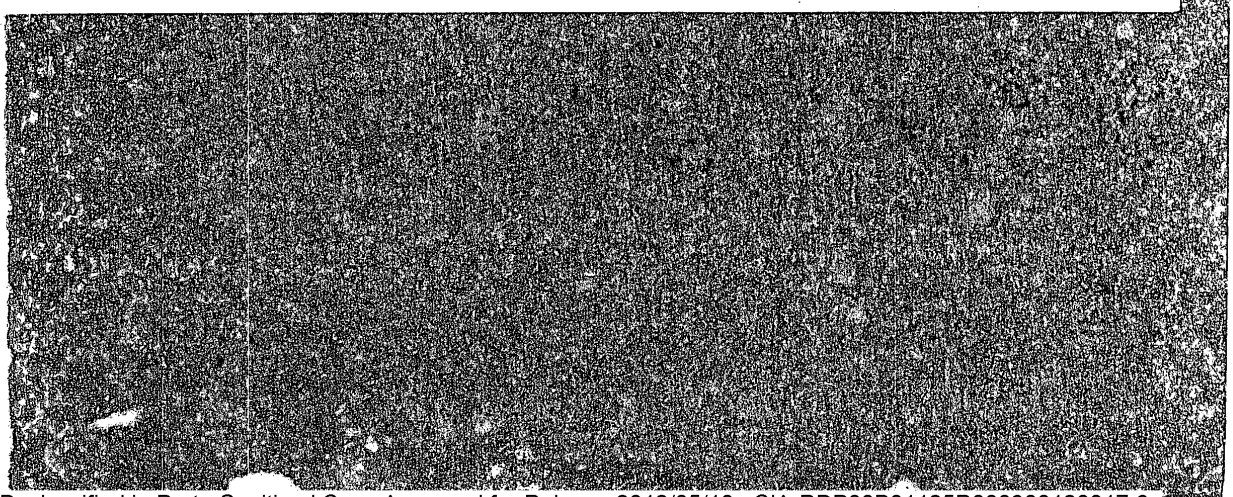
Nonuniform mobility of the individual and the capacity of a charge to "leak" from polymers and the body create conditions for exposure to a varying electrostatic field.

Considering the premises mentioned above, we developed a unique device by which to test the effect of electrostatic fields of different orientations, intensities, and periodicities on the human body. The device is a unique cylindrical capacitor, in which the test subject, grounded through the resistance of his shoes, plays the role of the inner plate. Voltage is fed to the outer plate from a high-voltage rectifier. Intensity is computed with a formula taking account of the geometric dimensions of the test

subject's body. A contact breaker we designed for the line supplying power to the outer cylinder is used to produced nonuniform periodicity in the intensity of the field, which is set on the basis of time-and-motion studies on the individual's mobility.

Experiments conducted with this device demonstrated that a 1,000 volt/cm electrostatic field can affect some functions of the human body associated with thermoregulation (circulation, perspiration, thermoreception, and so on).

This once again confirms the need for deeper research by which to hygienically assess electrostatic fields, which are one of the manifestations of electrostatically charged clothing made of natural and synthetic fibers.



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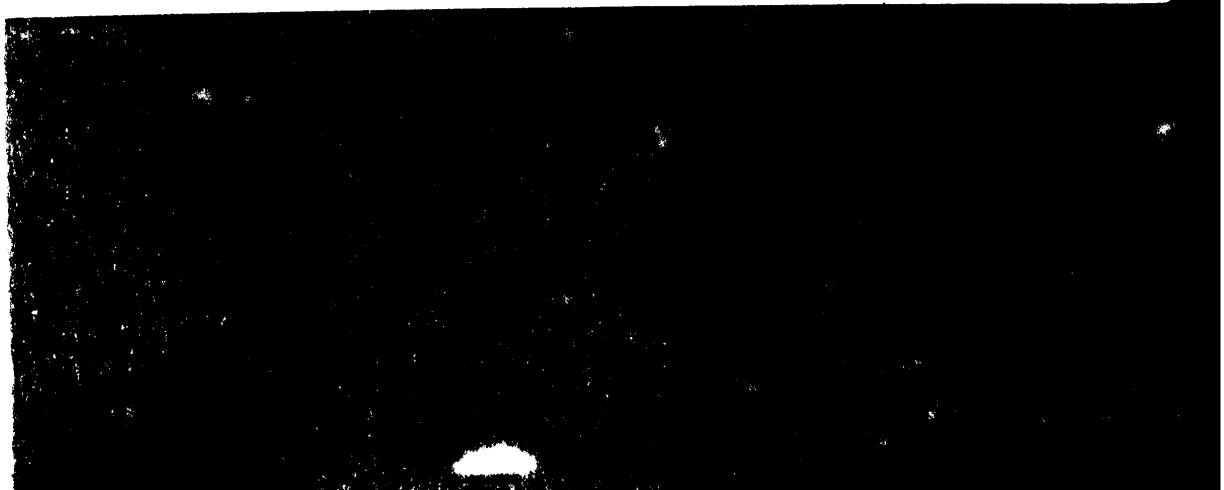

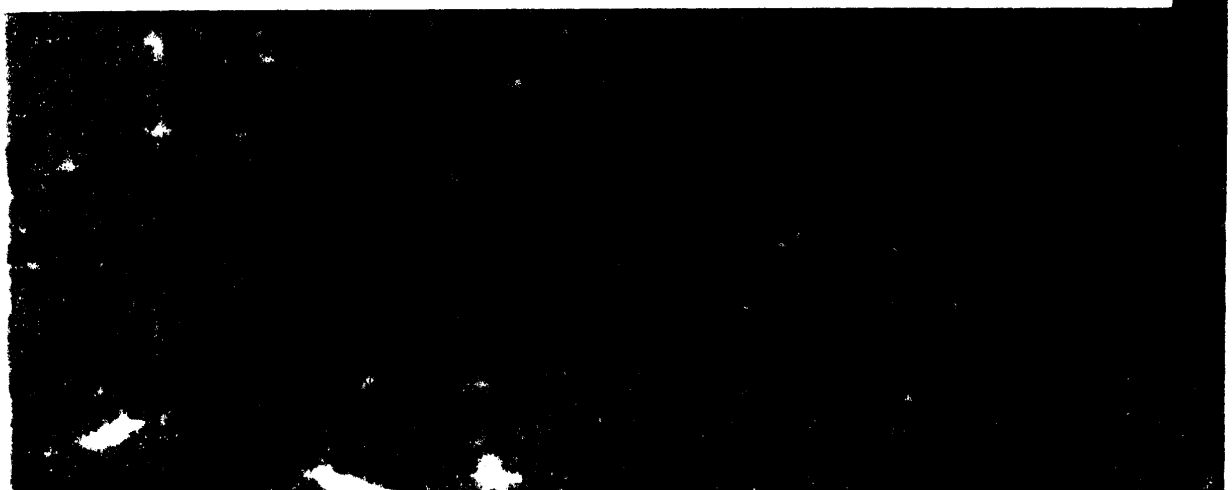

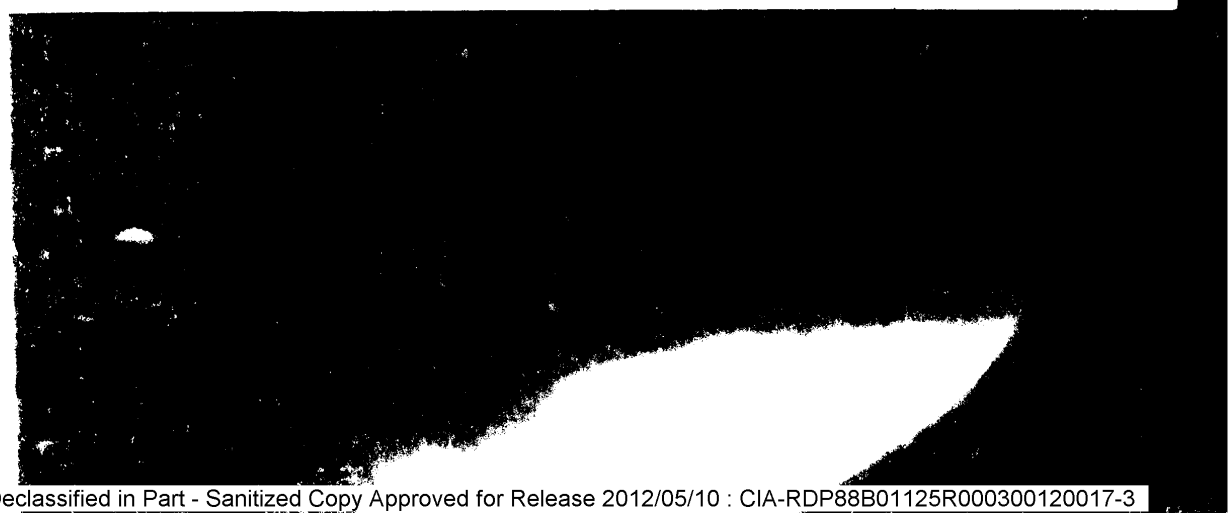

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